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(51) INT CL^5
B62D 9/02

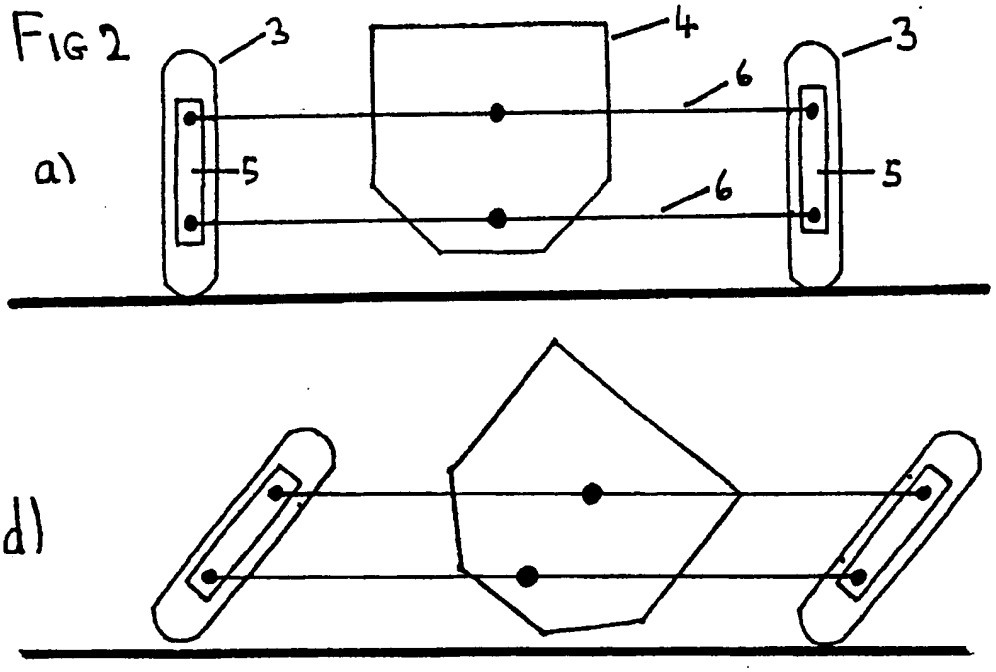
(52) UK CL (Edition M)
B7D DCF

(56) Documents Cited
GB 2155411 A **GB 0729190 A** **EP 0251906 A1**
US 4887829 A **US 4624469 A** **US 4484648 A**

(58) Field of Search
UK CL (Edition L) **B7D DCF**
INT CL^5 **B62D 9/02**

(54) Banking suspension

(57) A form of vehicular suspension which duplicates the dynamic properities of a motor/pedal bike's suspension and which is also capable of keeping the vehicle upright when it is moving slowly or is stationary is achieved by having at least one pair of wheels 3 laterally disposed about the vehicle's body 4 in conjunction with a mechanism connecting the wheel's uprights and the body in such a manor as to allow them to rotate freely and in unison about the wheel's contact points with the ground. Thus the machine may be banked into corners like a bike. The vehicle's angle of lean is controlled by use of wheel gyroscopic forces. At low speed and when stationary the mechanism is locked in rotation relative to the body and thus the vehicle becomes in effect a narrow car. As the rider/driver does not have to be able to touch the ground with his feet to stabilise the vehicle, it may be fully enclosed, and therefore has the potential to be as safe as car.



GB 2 279 047 A

The claims were filed later than the filing date within the period prescribed by Rule 25(1) of the Patents Rules 1990.

FIG 1 a)

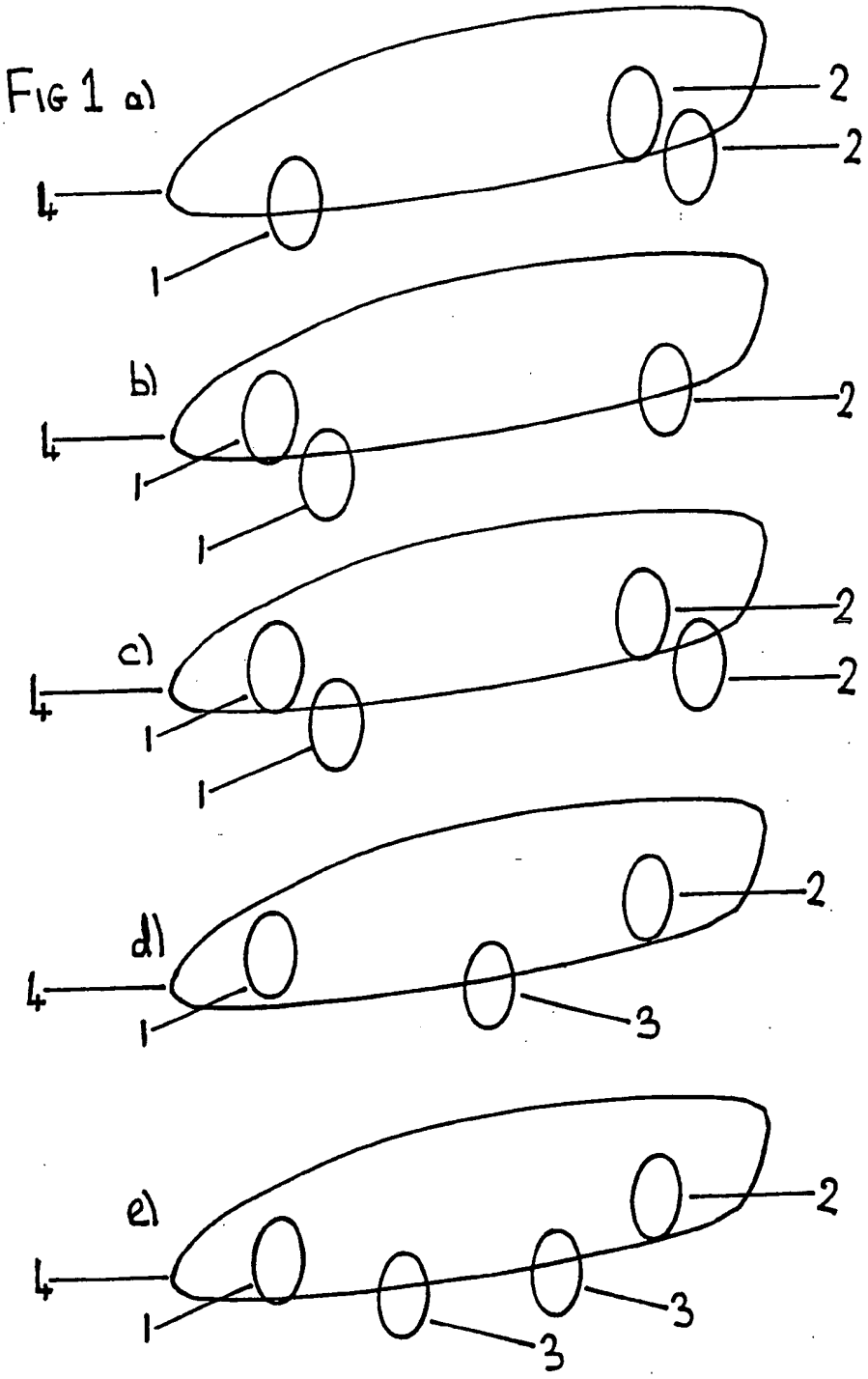


FIG 2

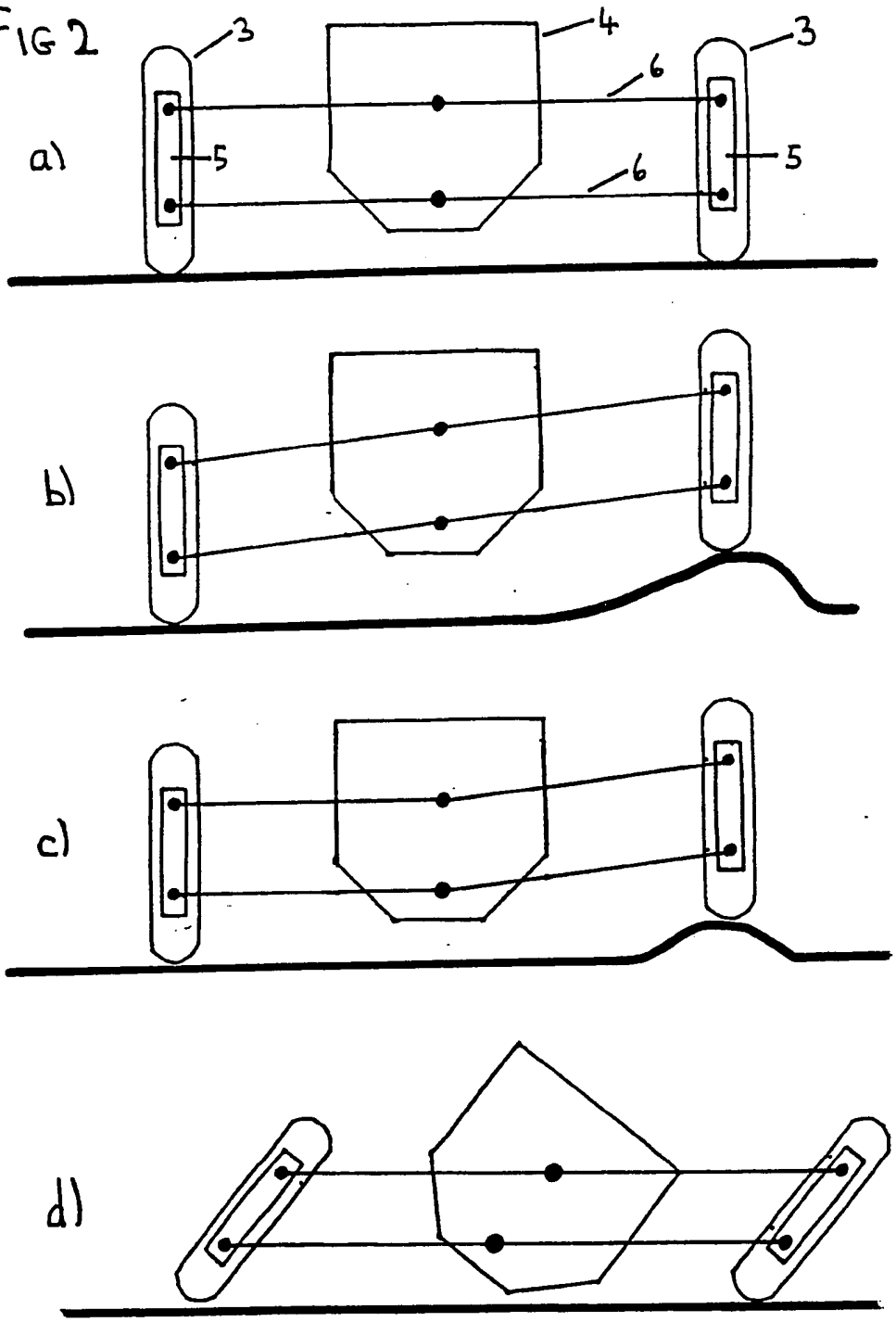
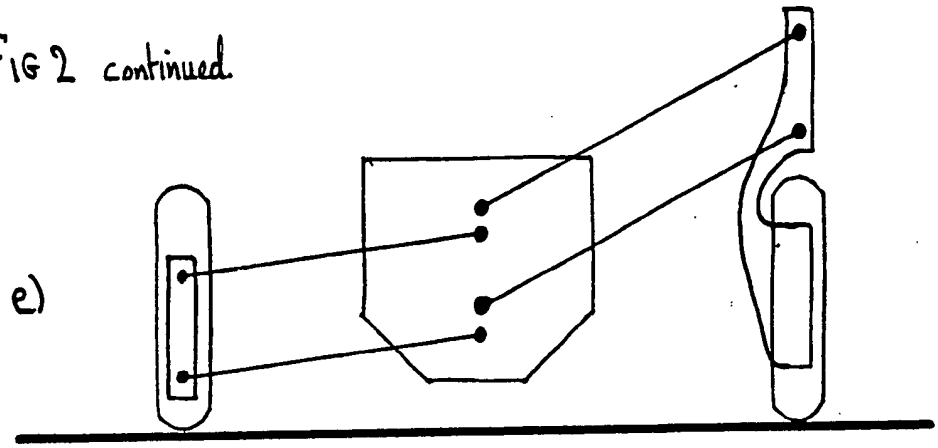
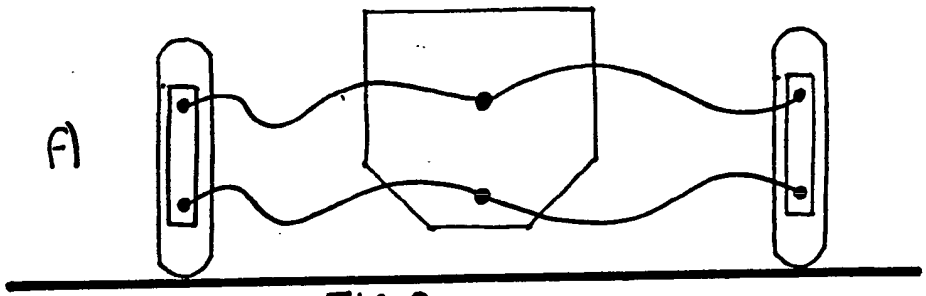


FIG 2 continued





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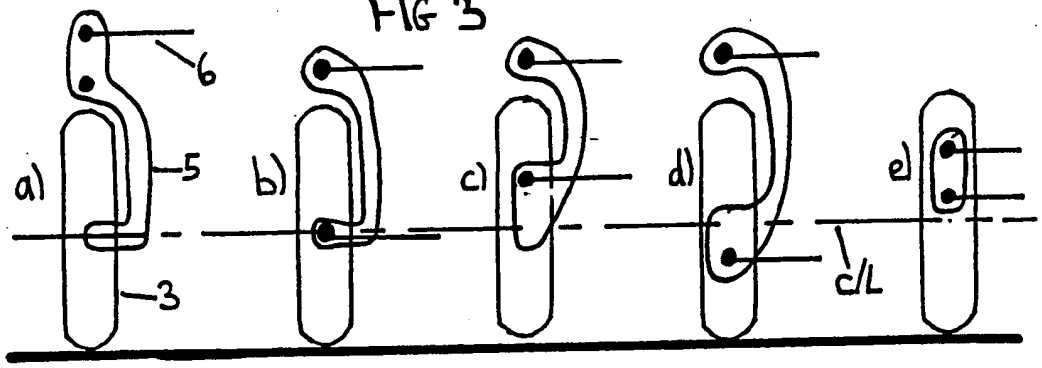


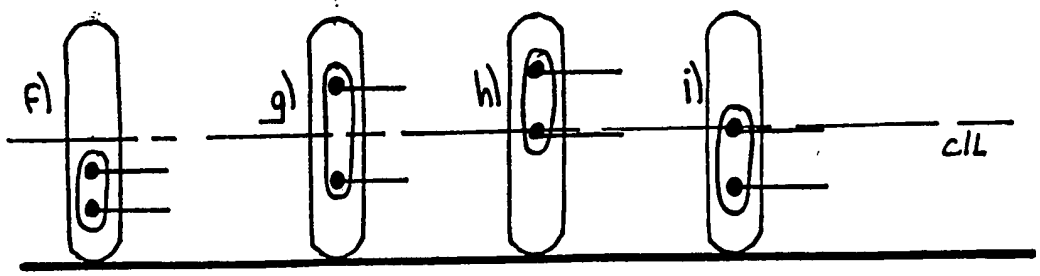


FIG4

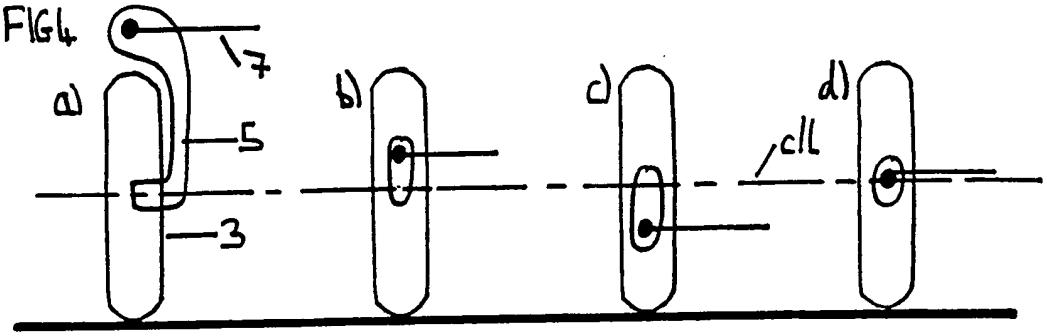
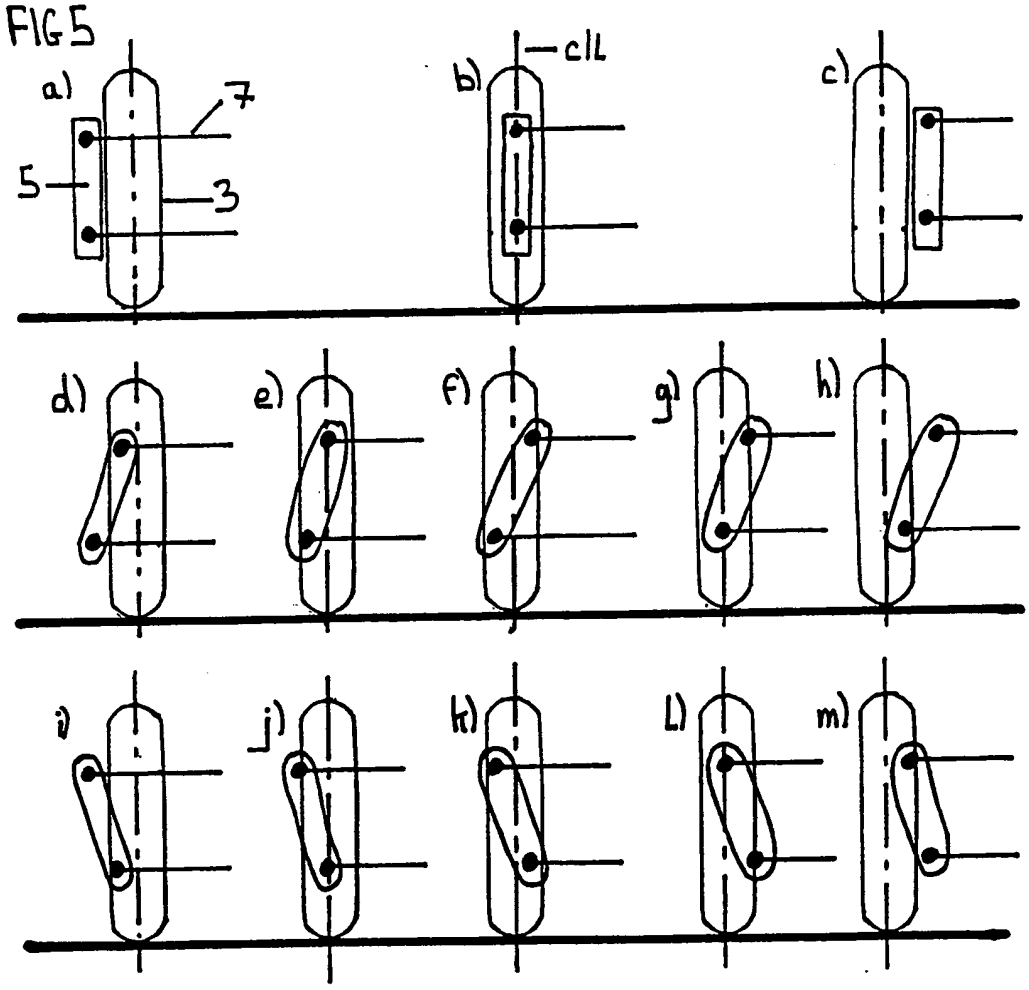


FIG5



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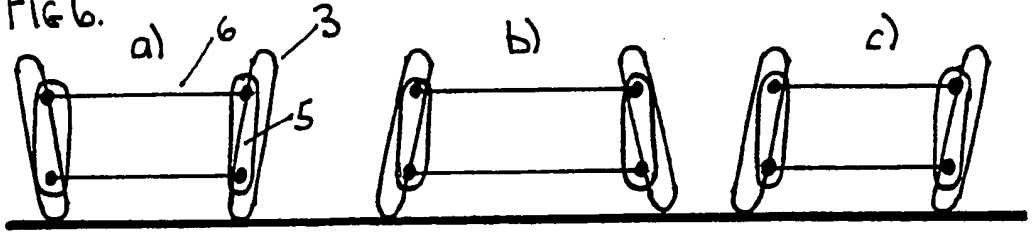


FIG 7

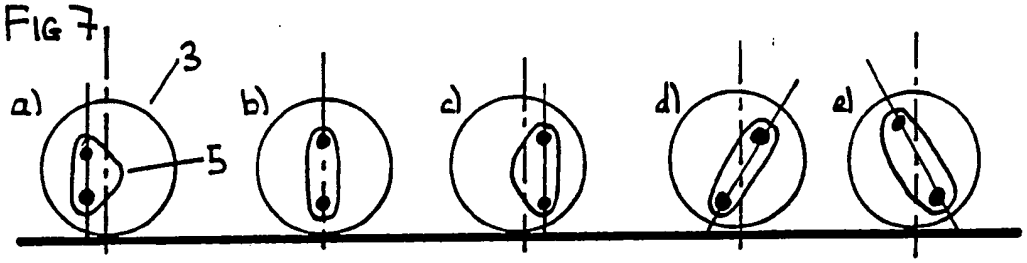
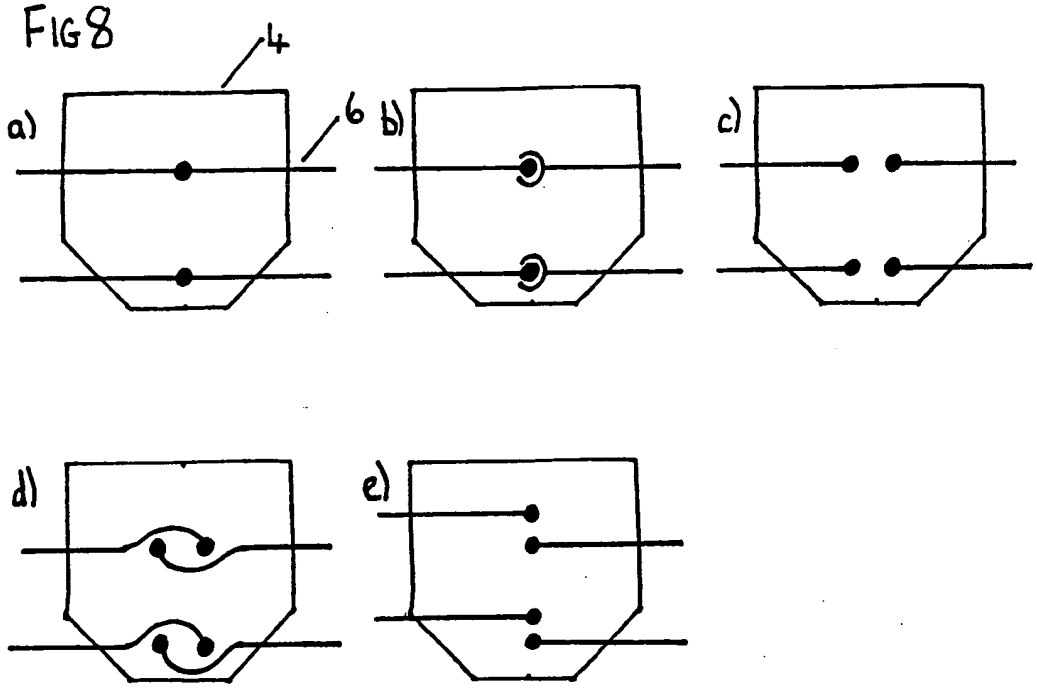


FIG 8



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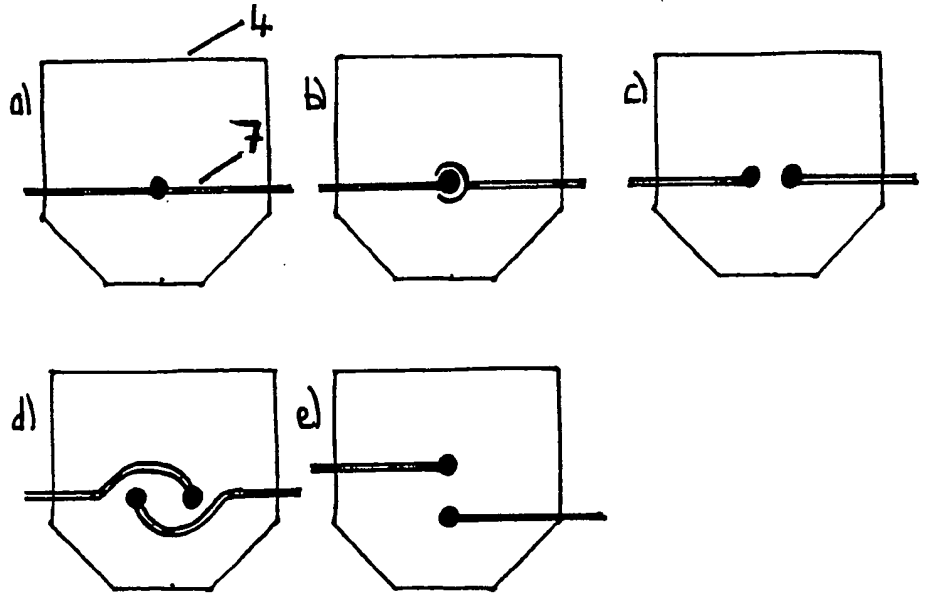


FIG 10

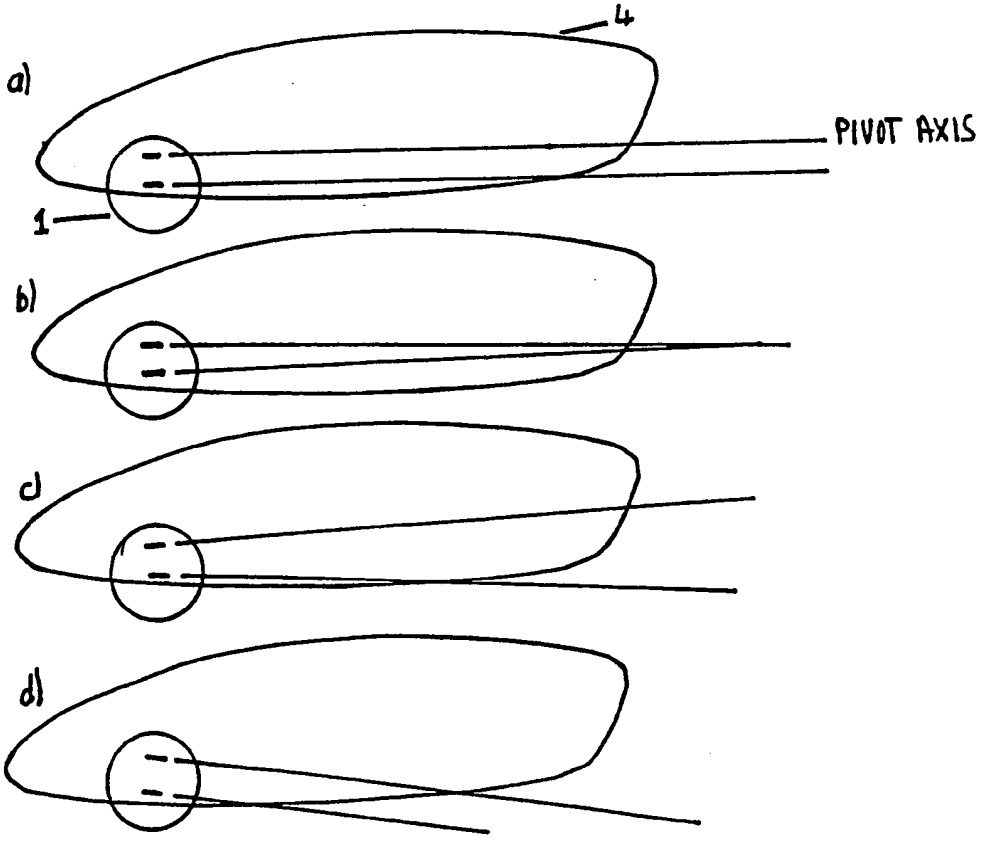
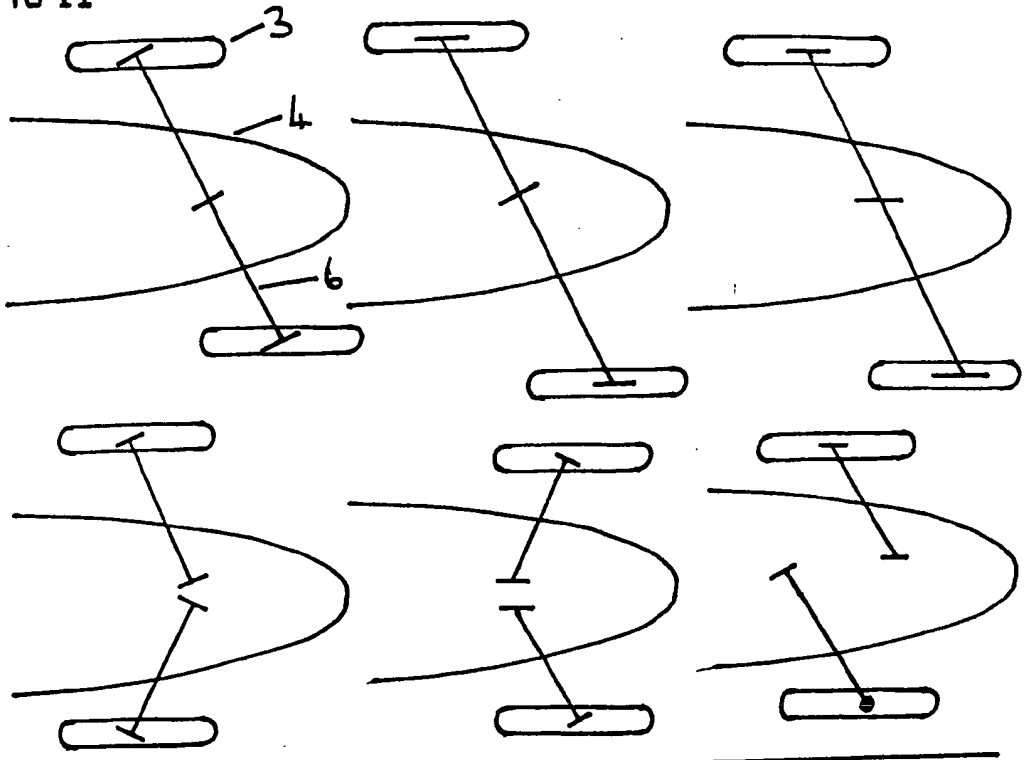


FIG 11



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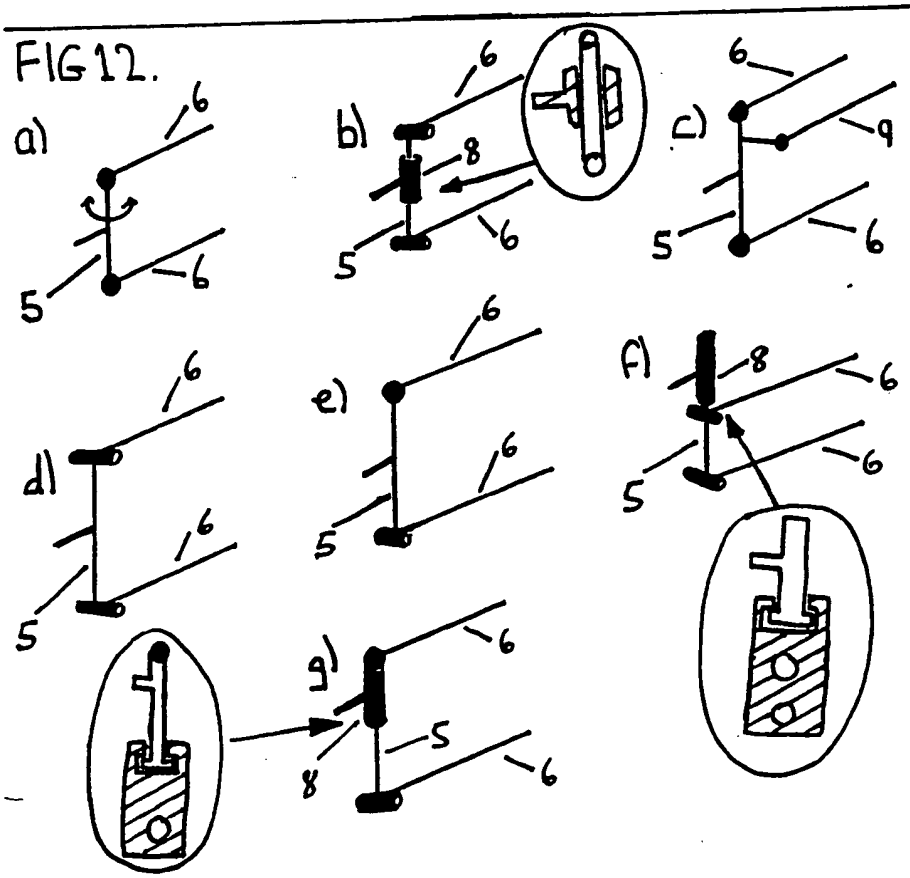
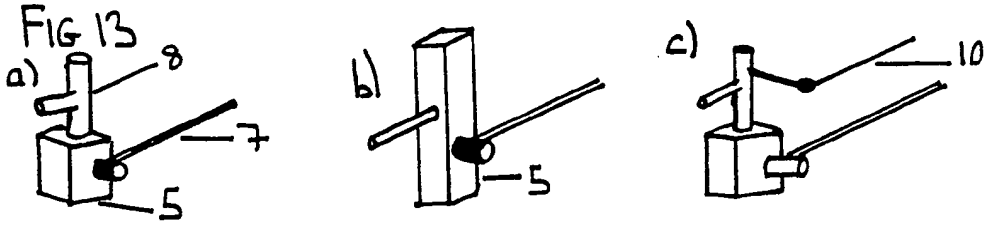


FIG 13



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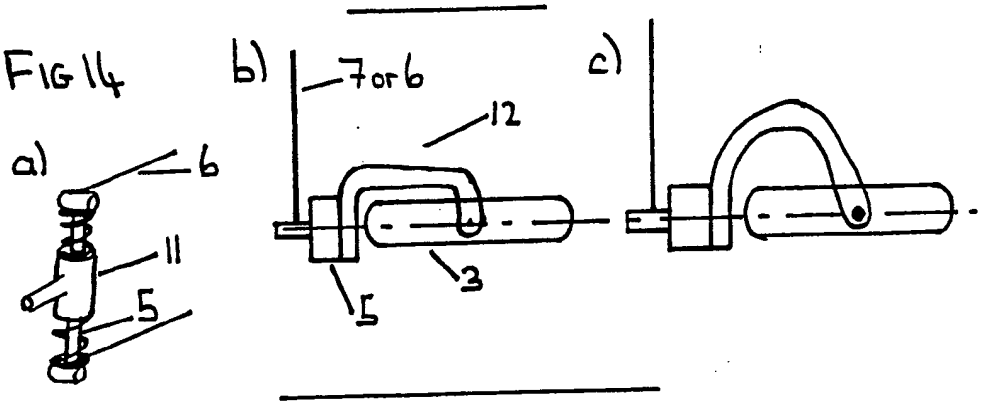


FIG 15

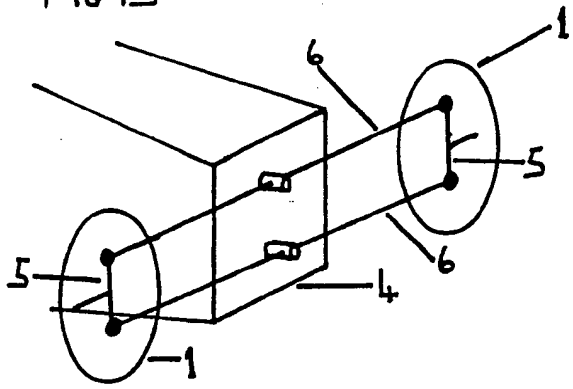


FIG1b.

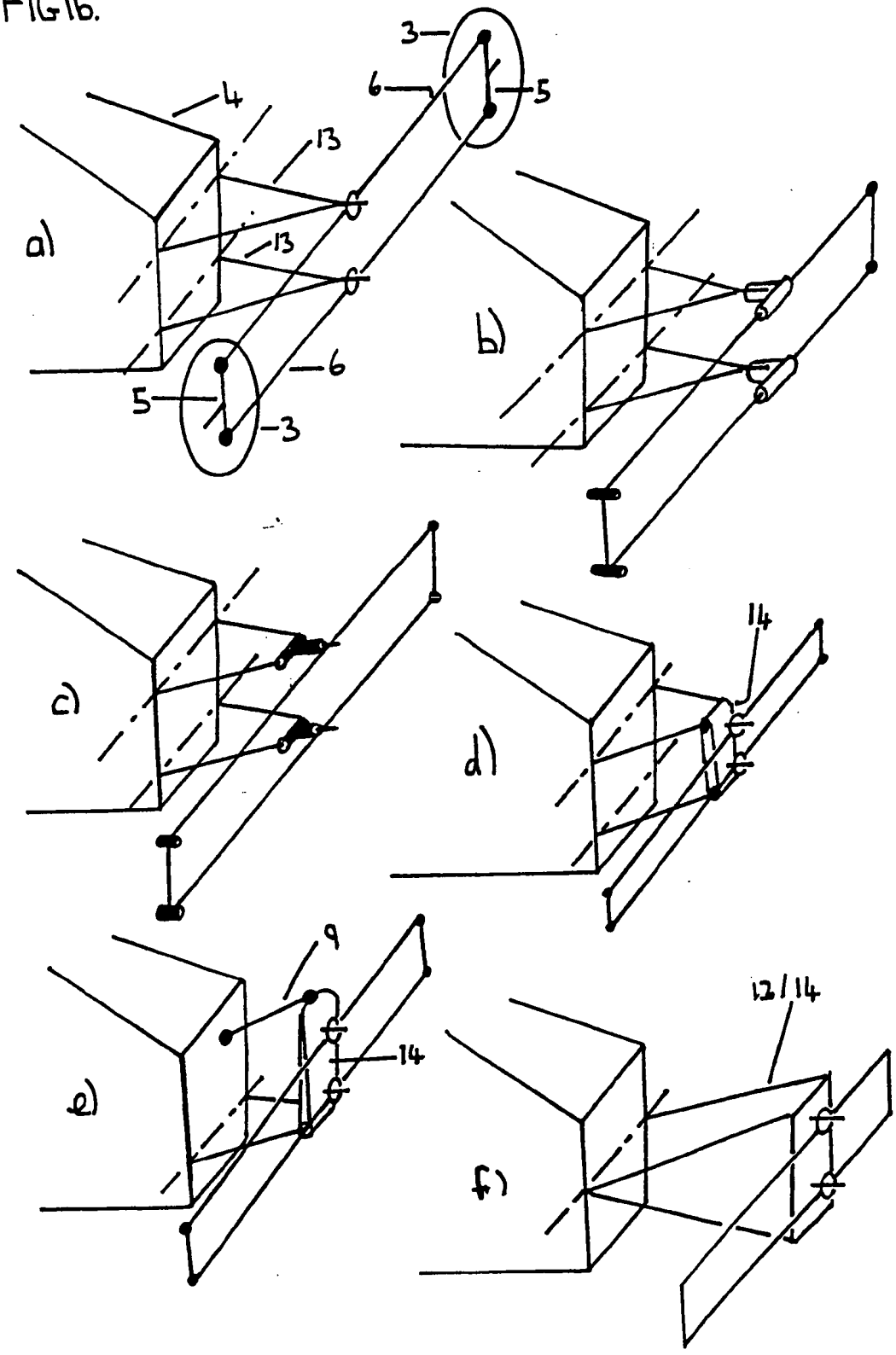


FIG 17

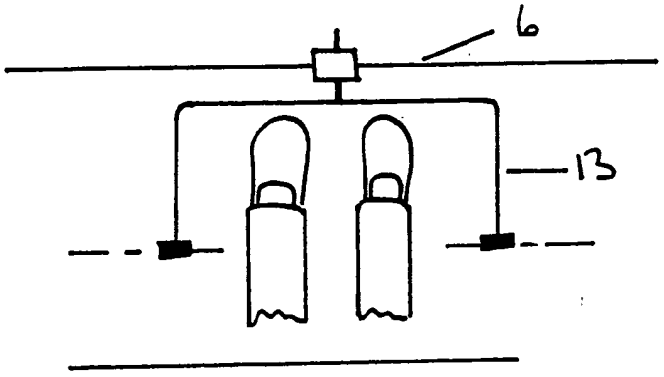


FIG 18

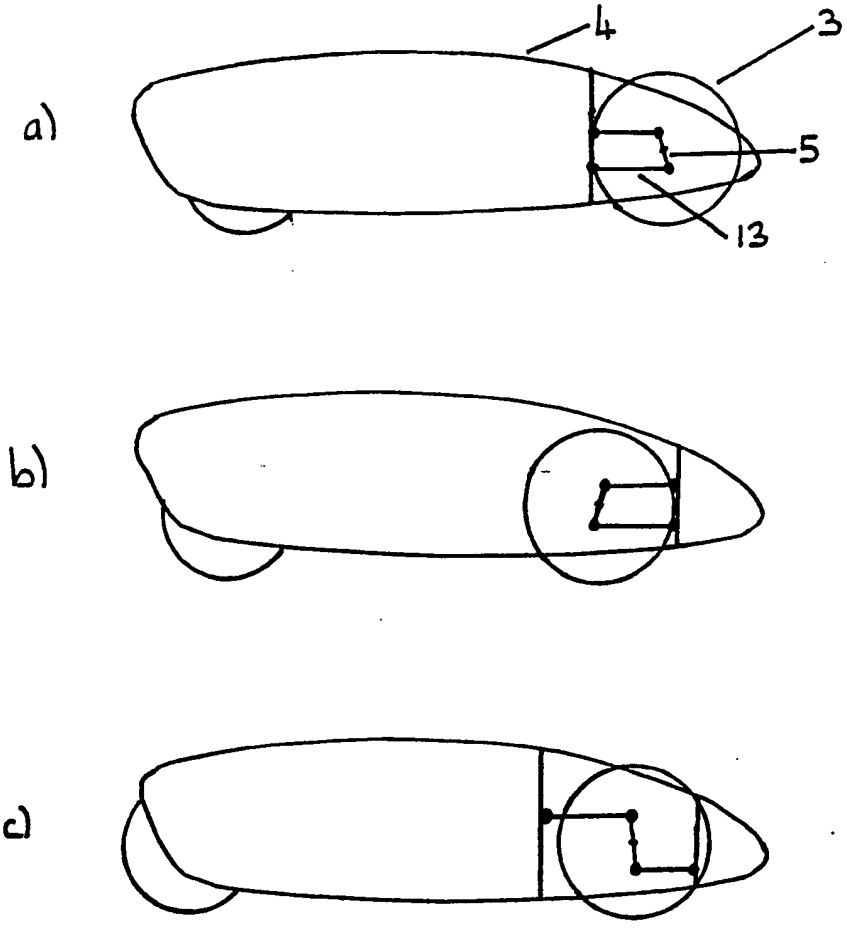
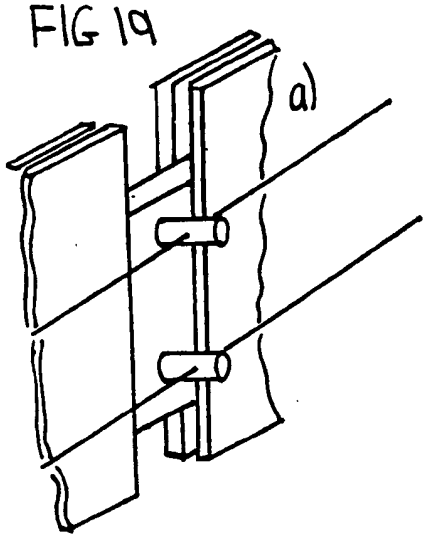
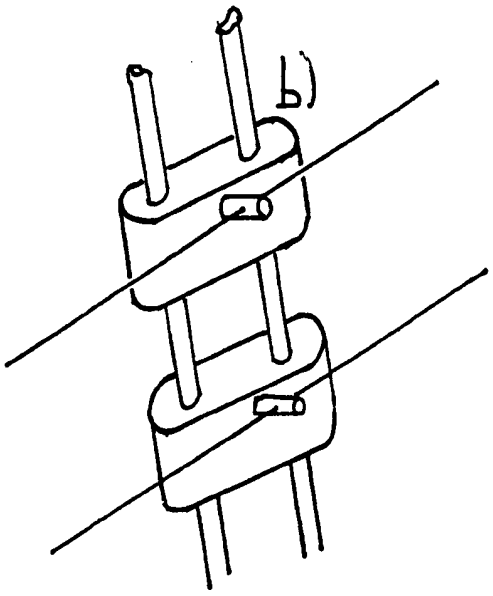
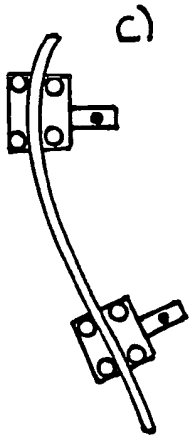


FIG 19







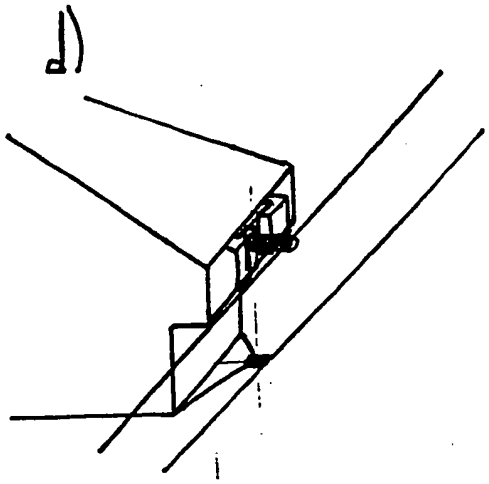


FIG 20

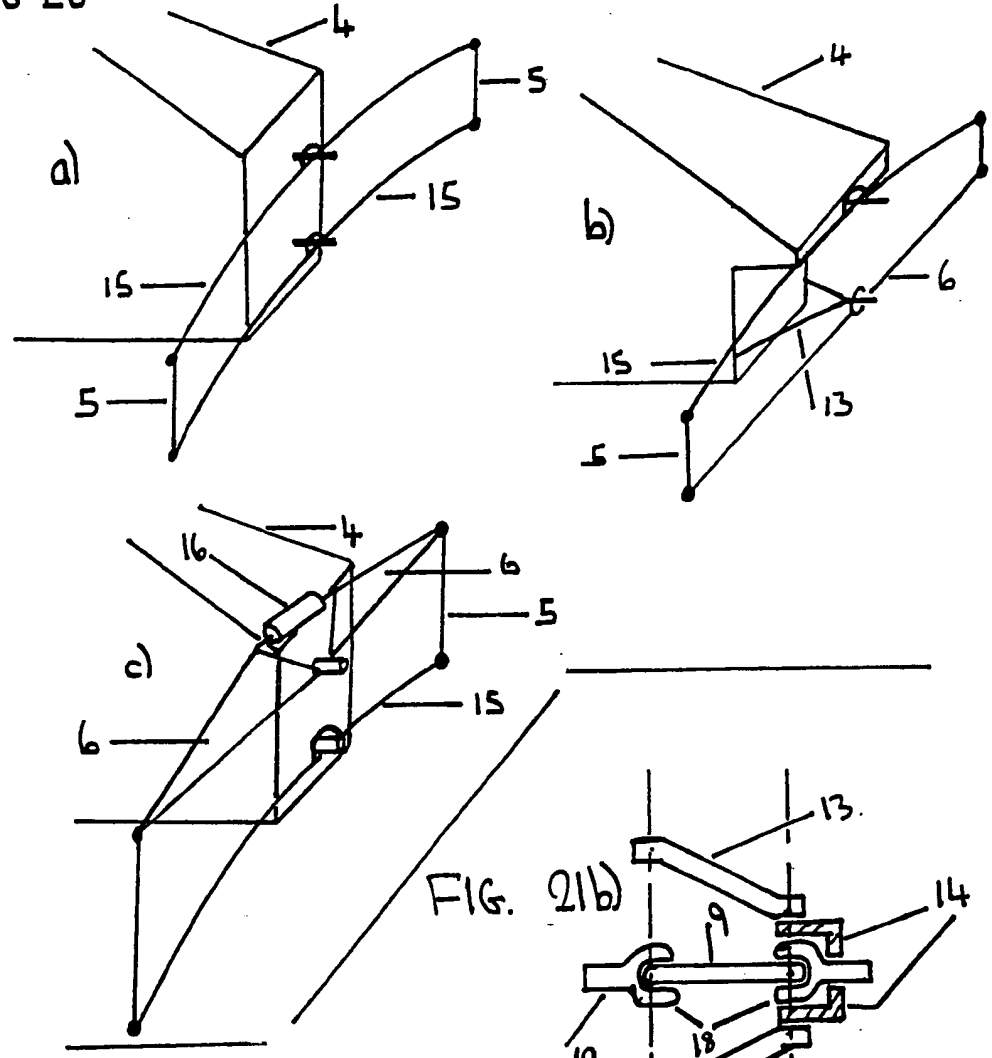


FIG. 21b)

FIG 21

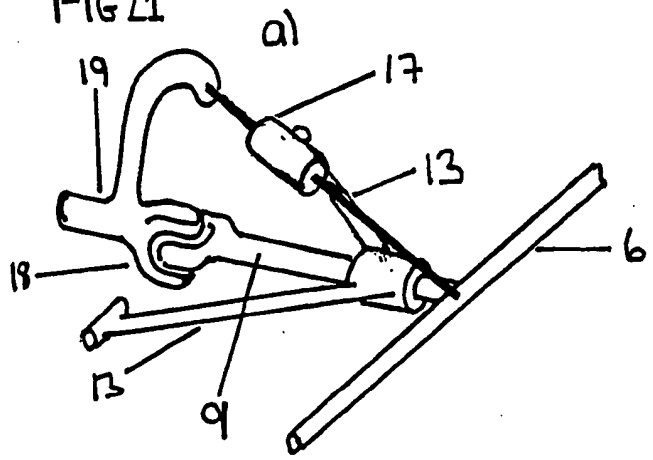
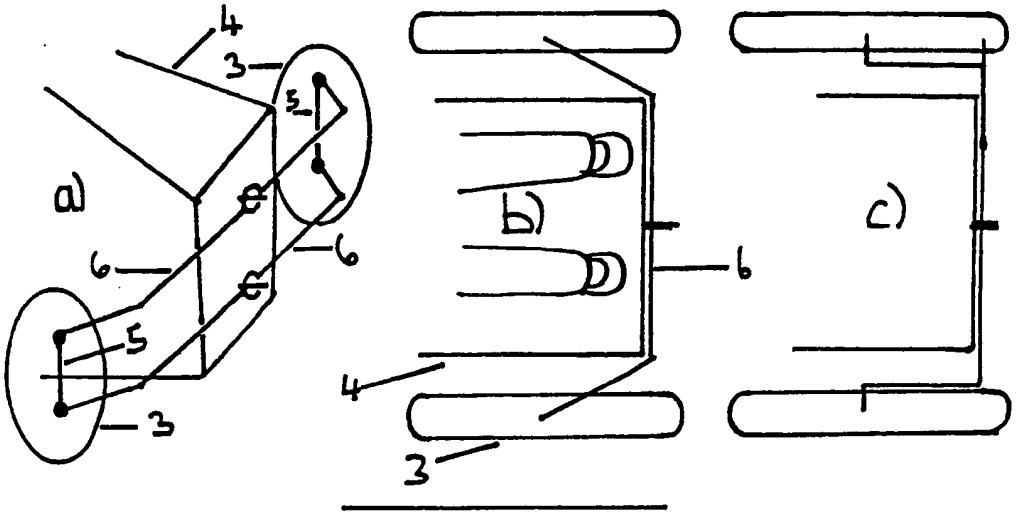


FIG22



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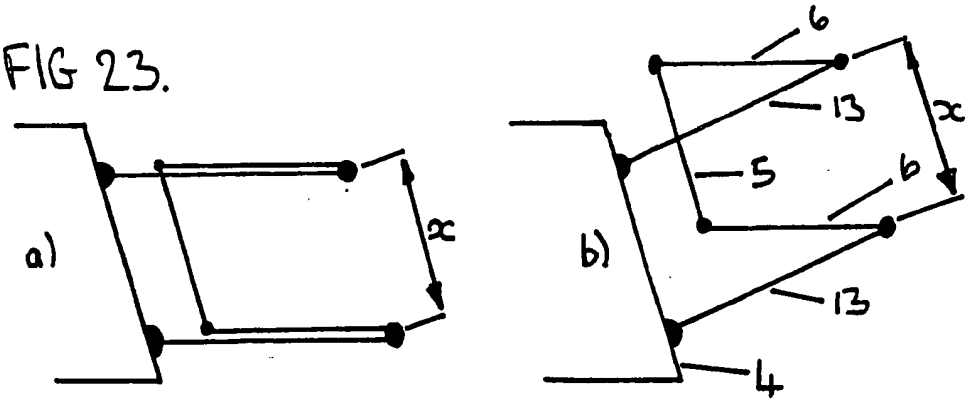

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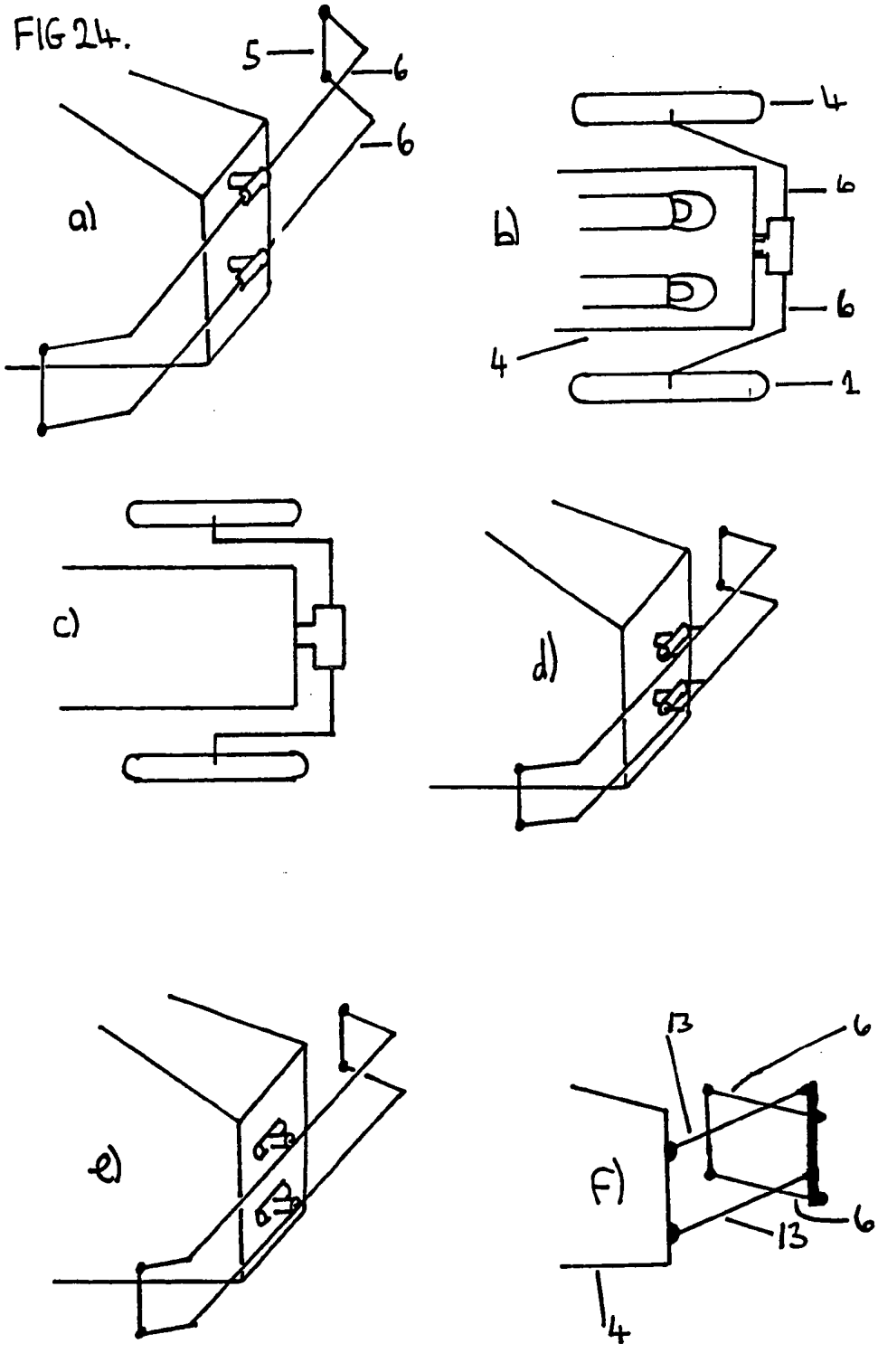

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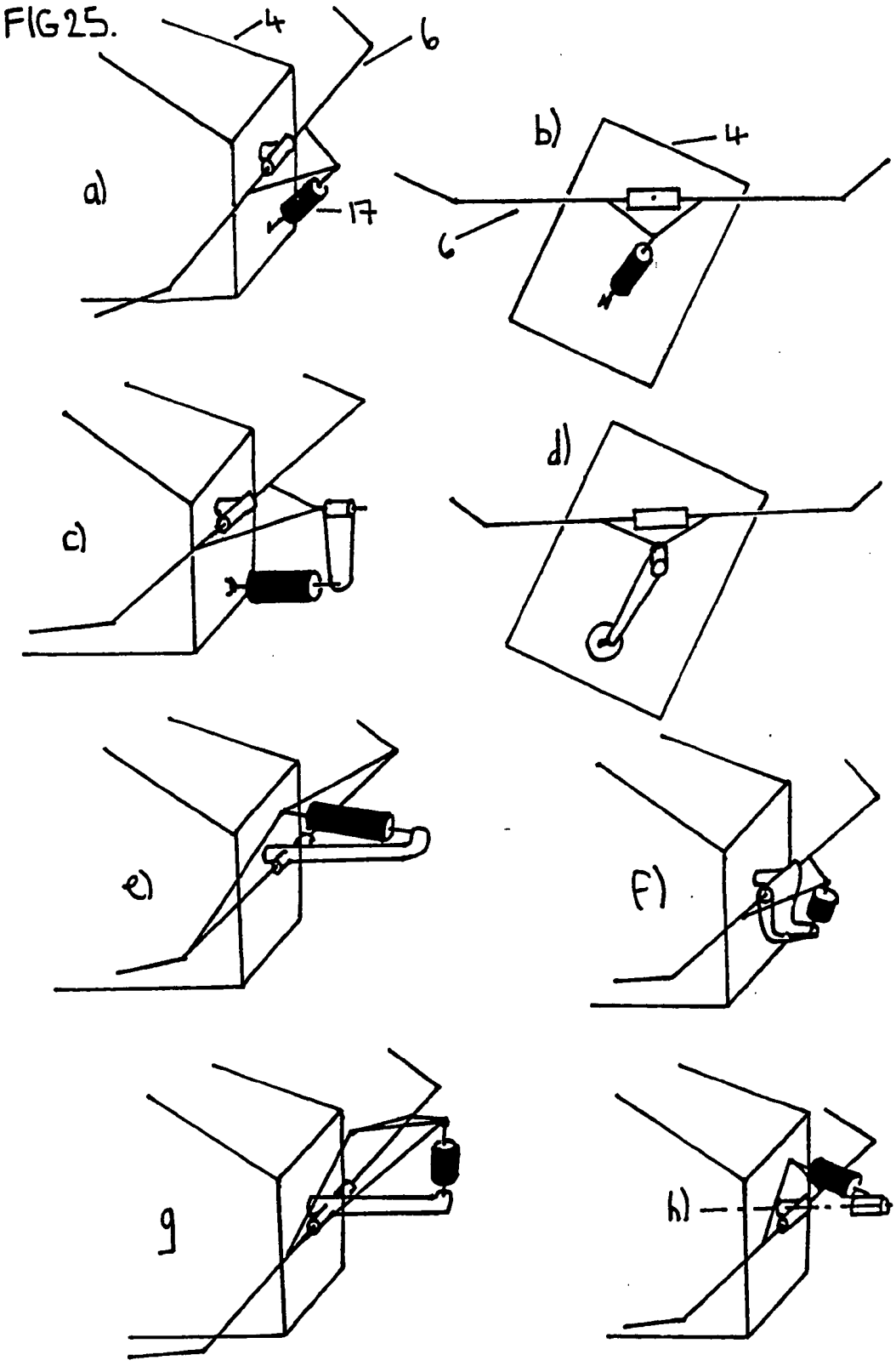
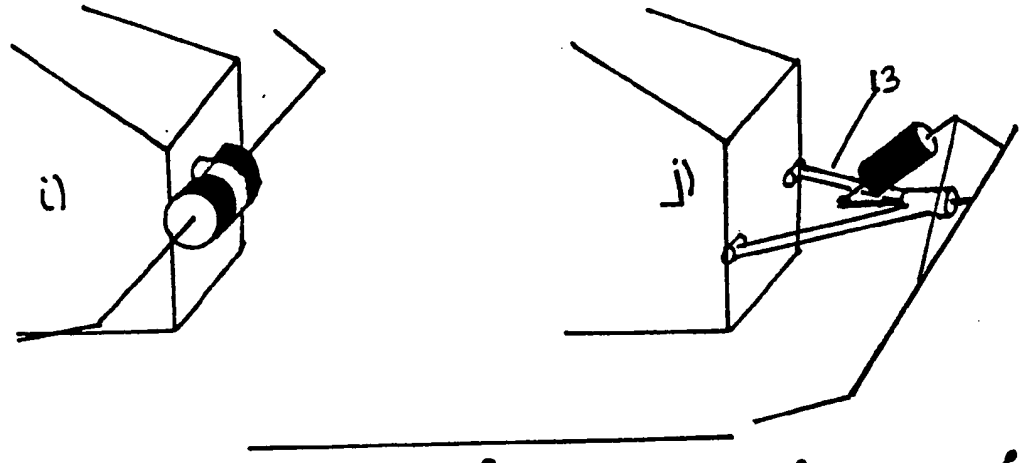


FIG 25 cont.



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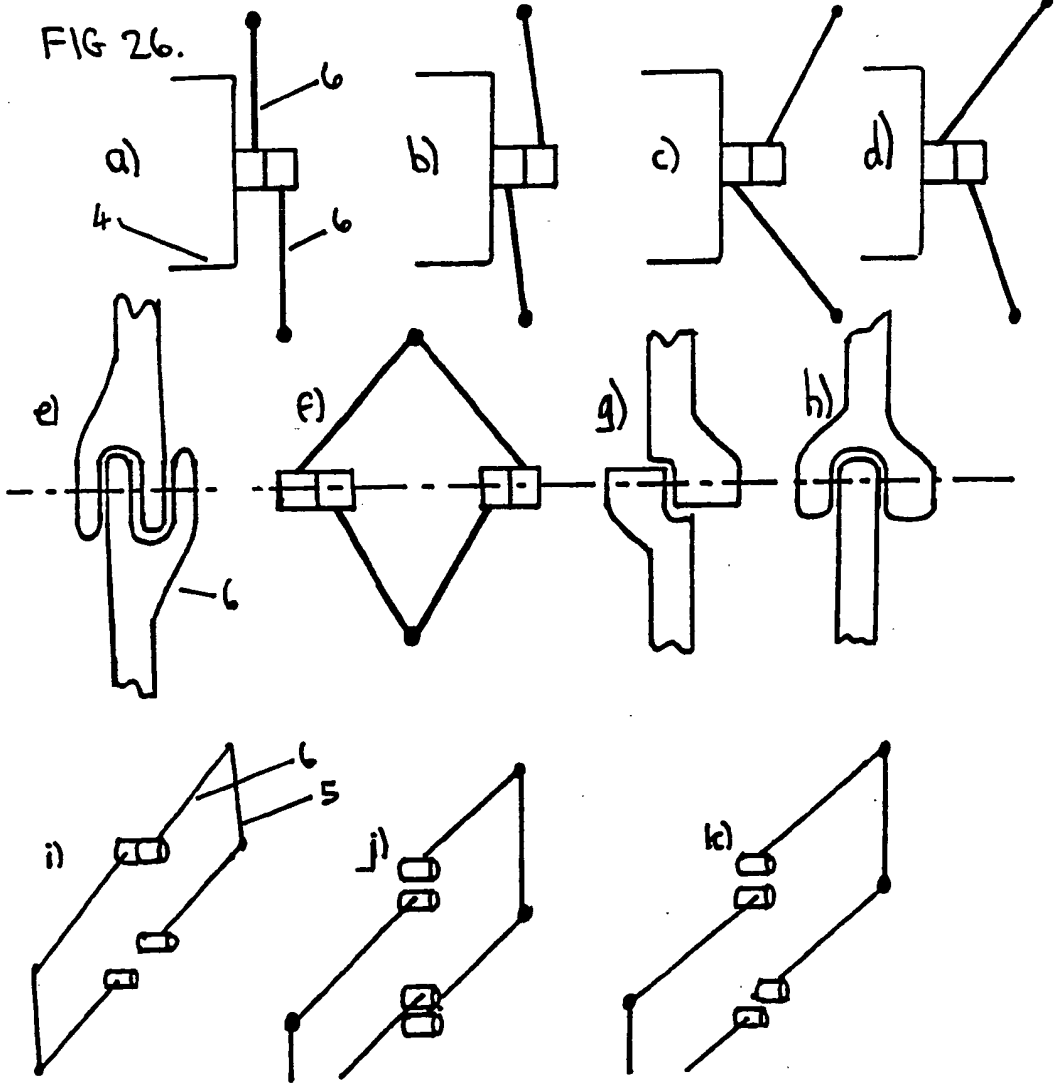

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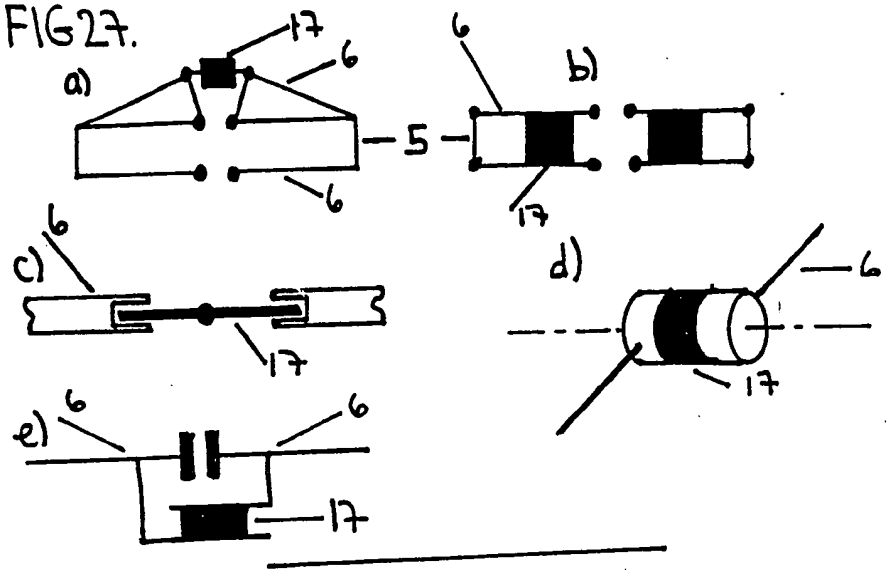

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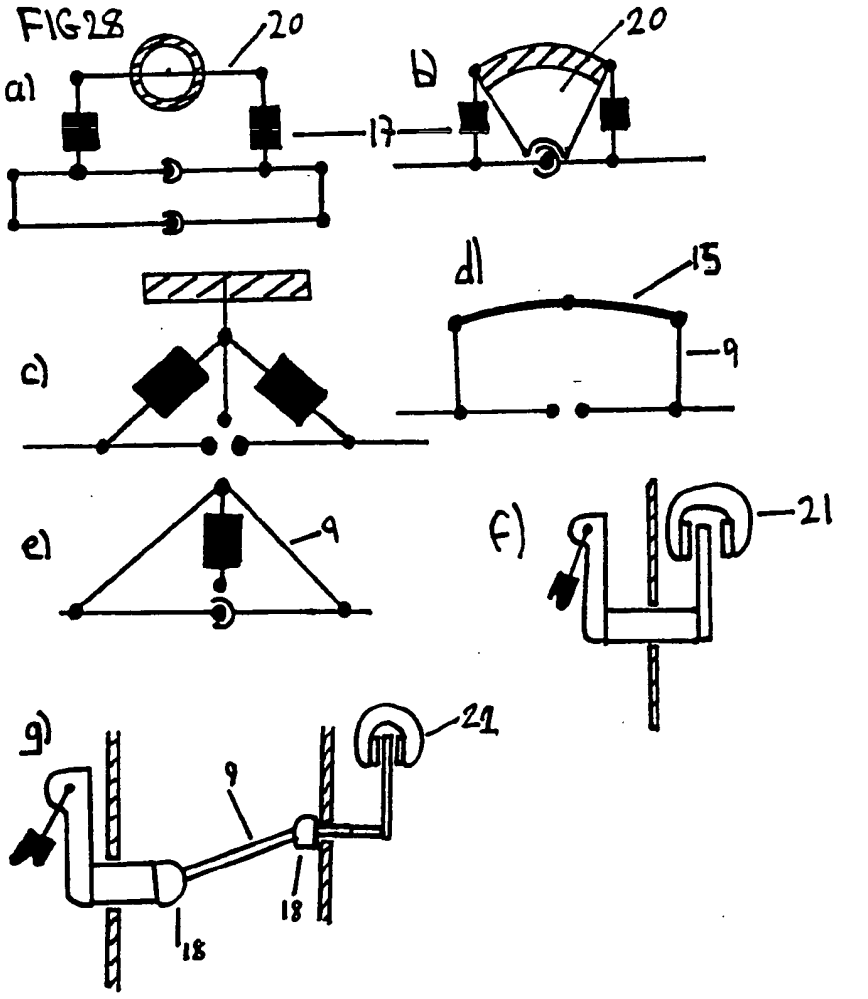

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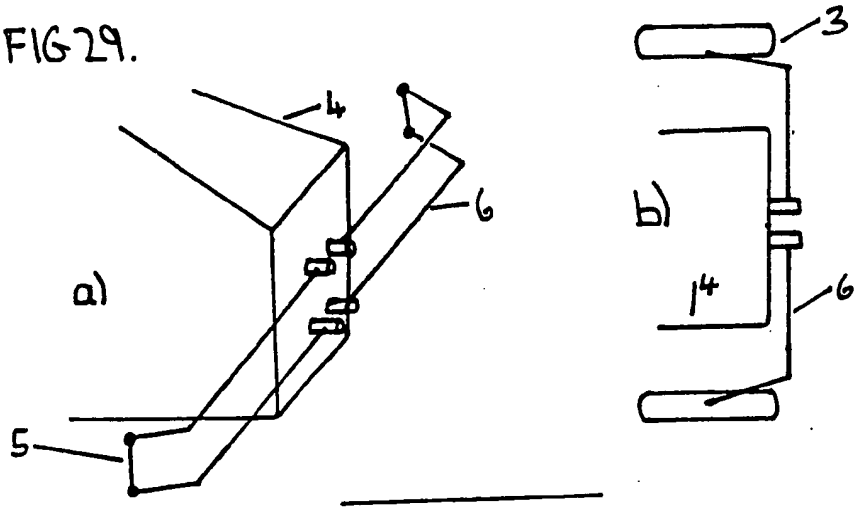
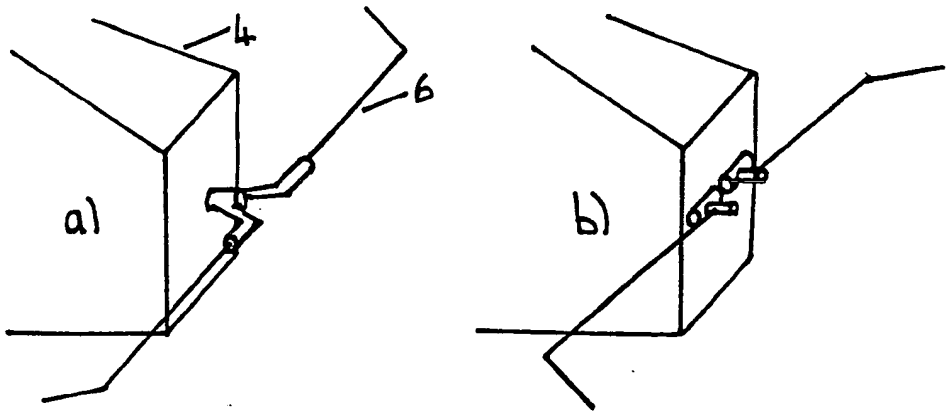


FIG 30



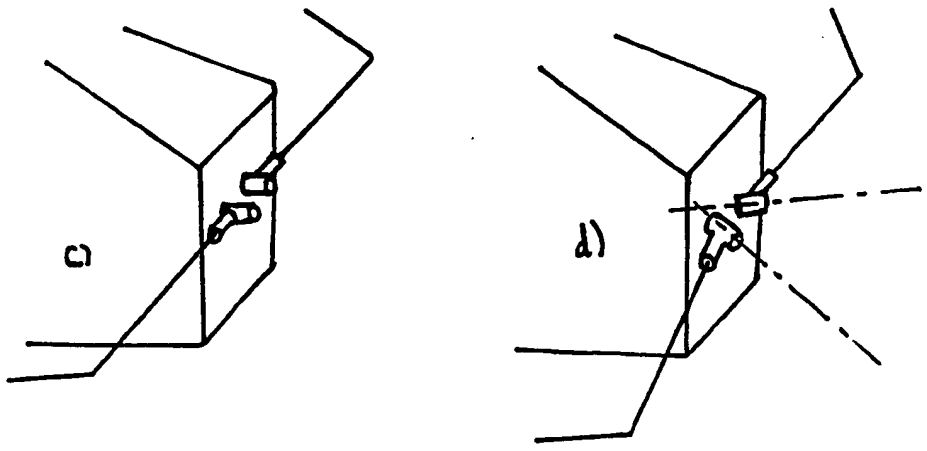


FIG 31

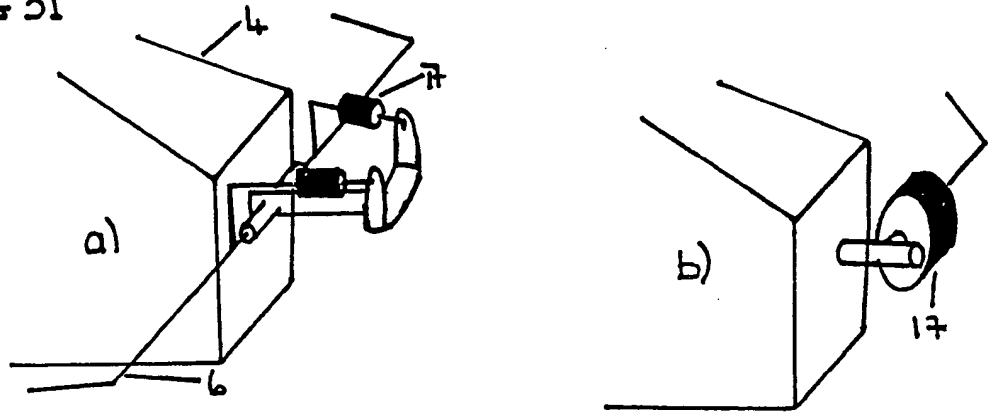


FIG 32

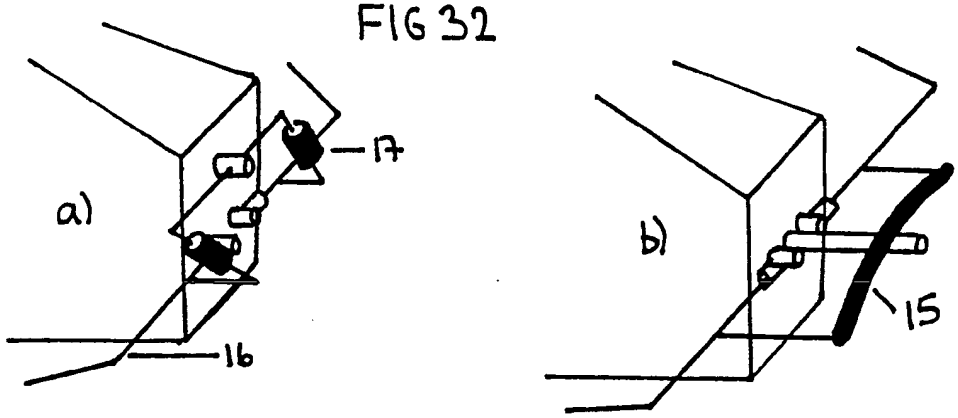
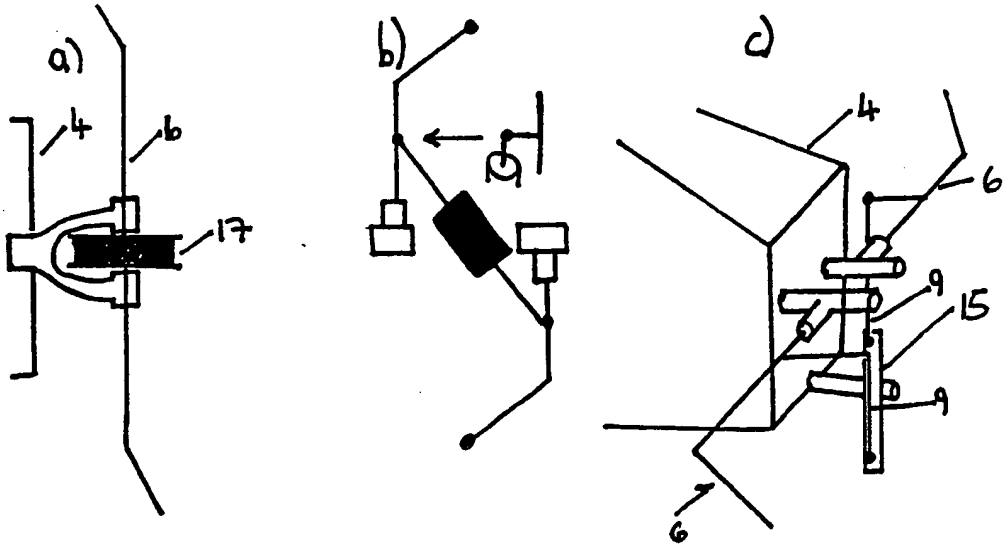


FIG 33



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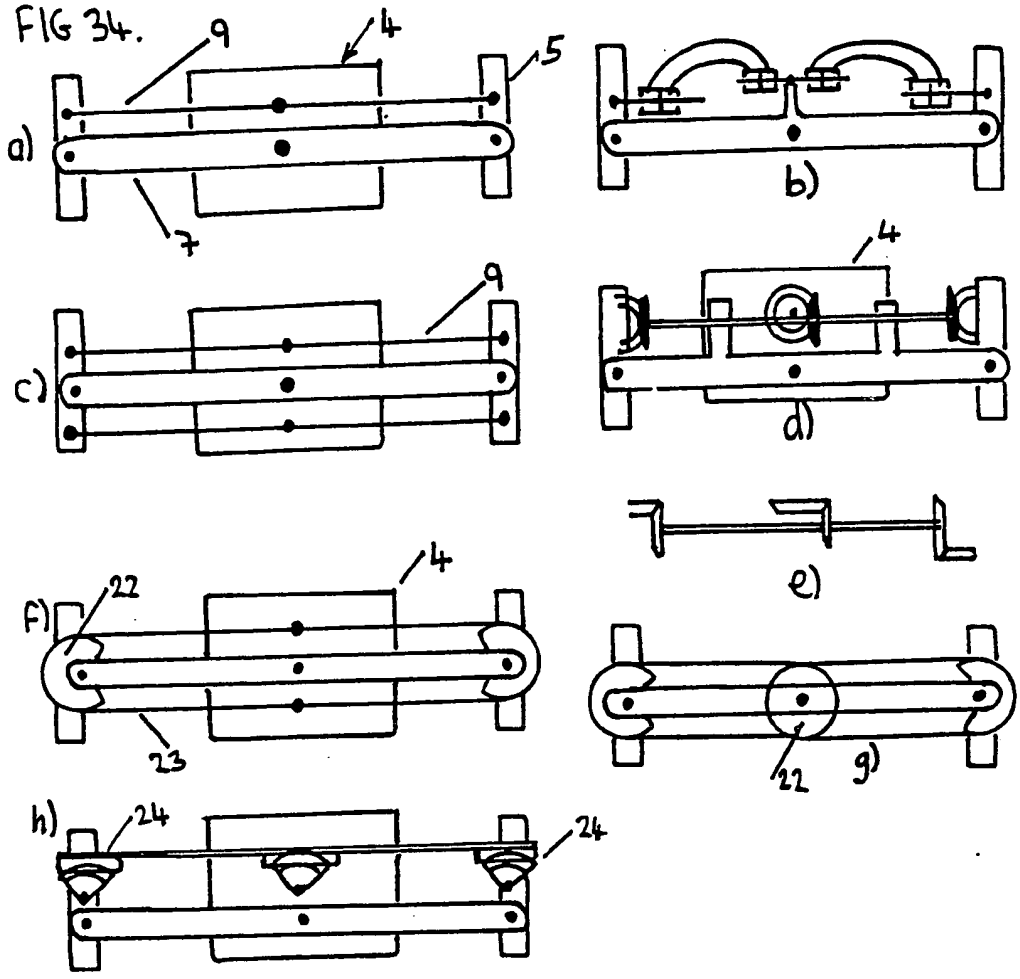


FIG35

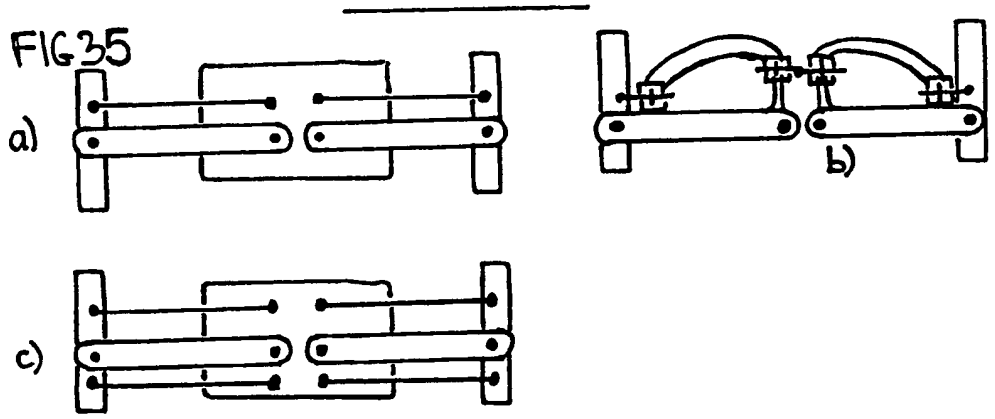
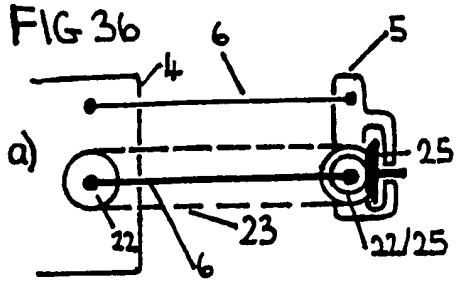
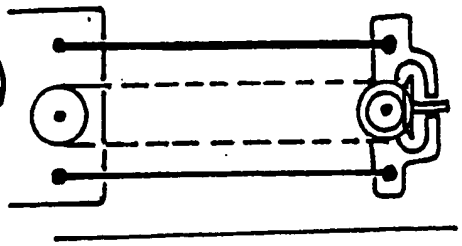


FIG 36





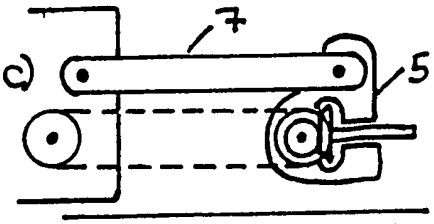


FIG 37

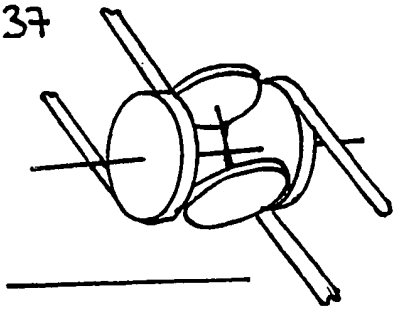


FIG 38

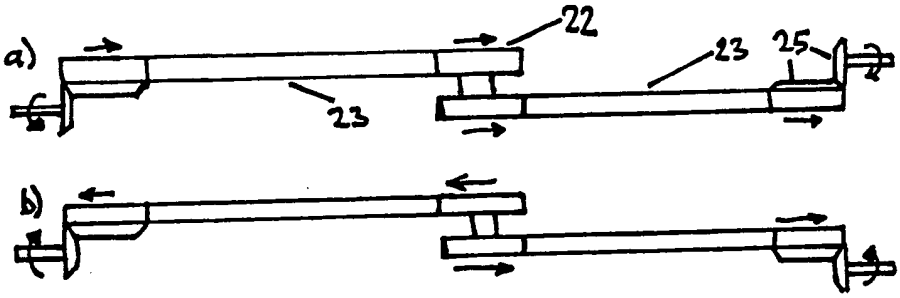
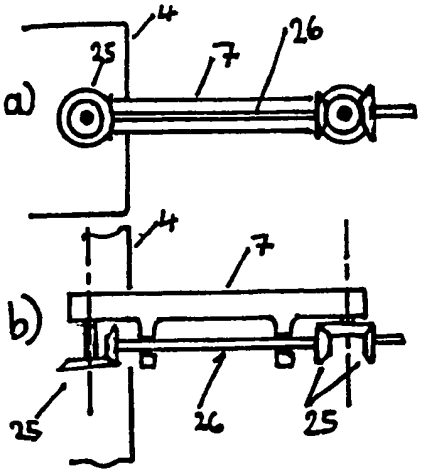


FIG 39



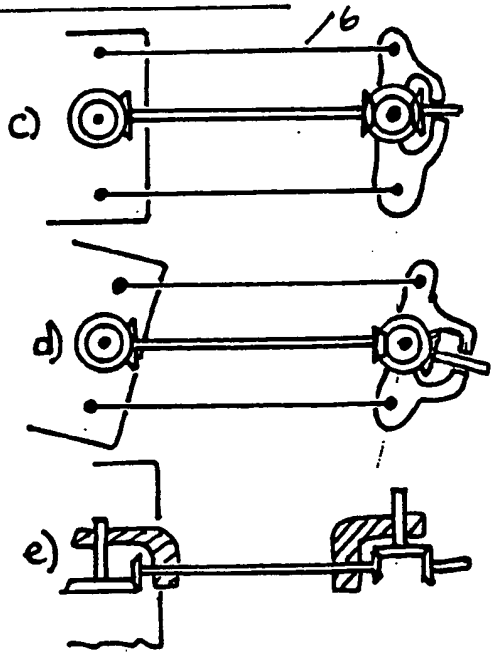


FIG 40

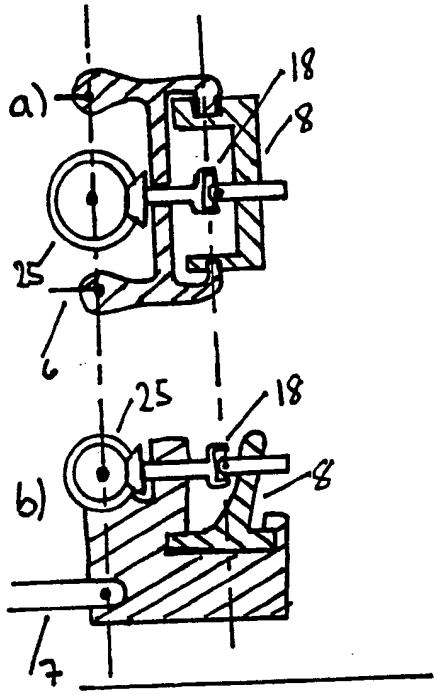


FIG 41

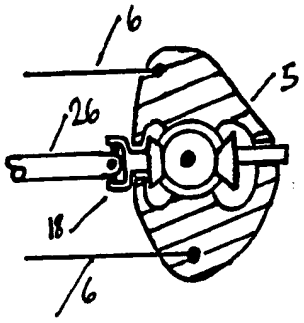


FIG 42

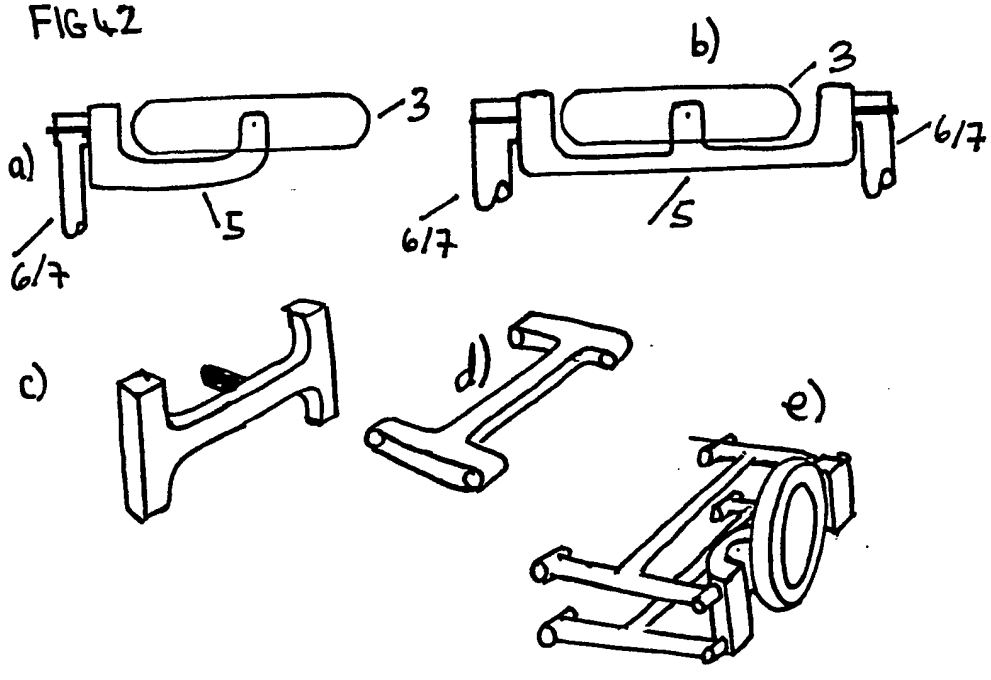


FIG43

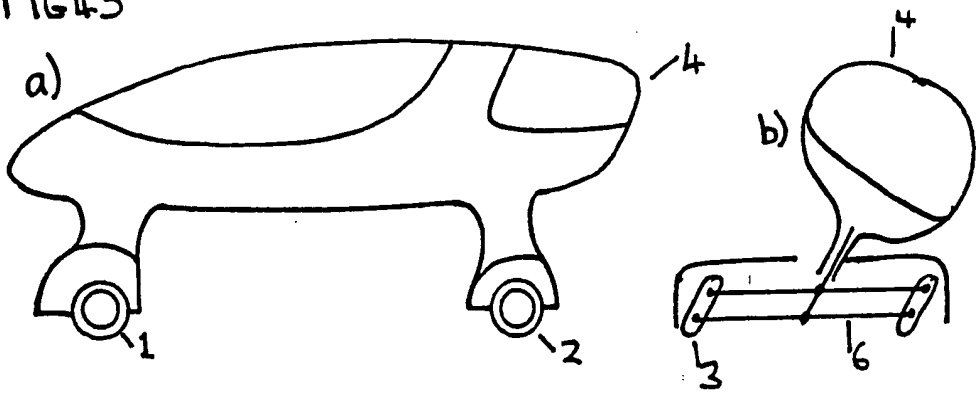


FIG44

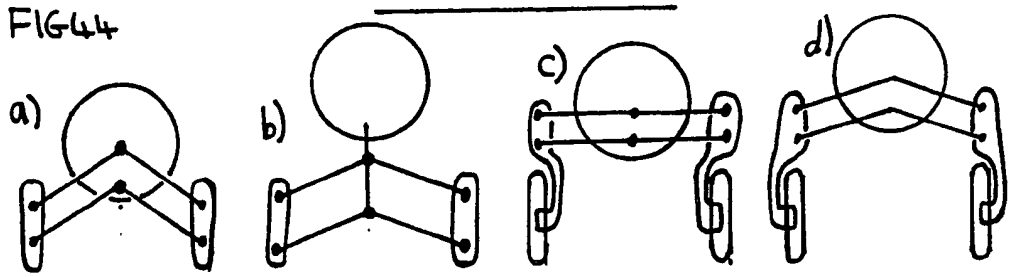


FIG 45

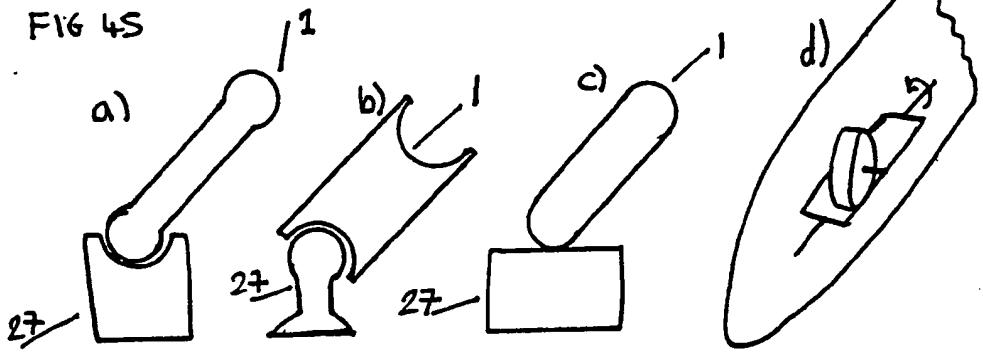


FIG 46

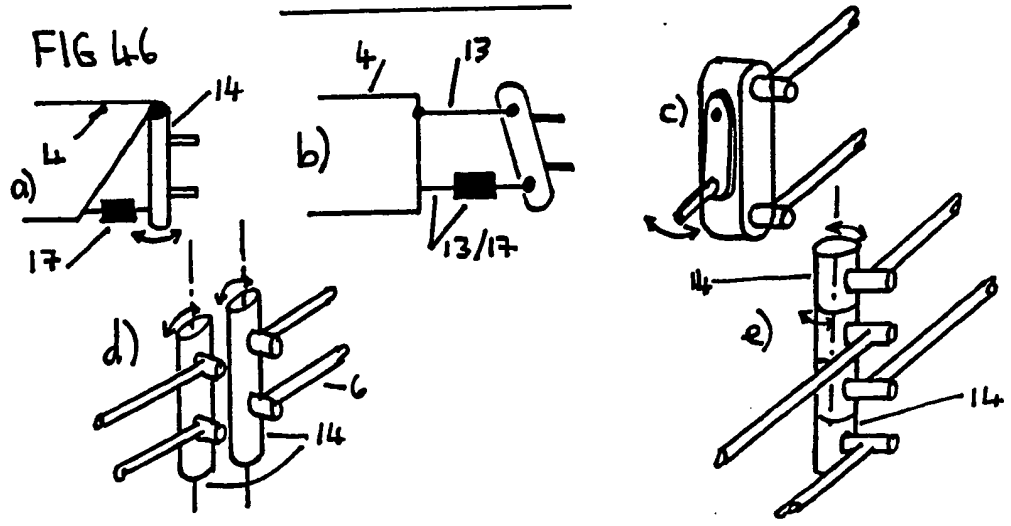
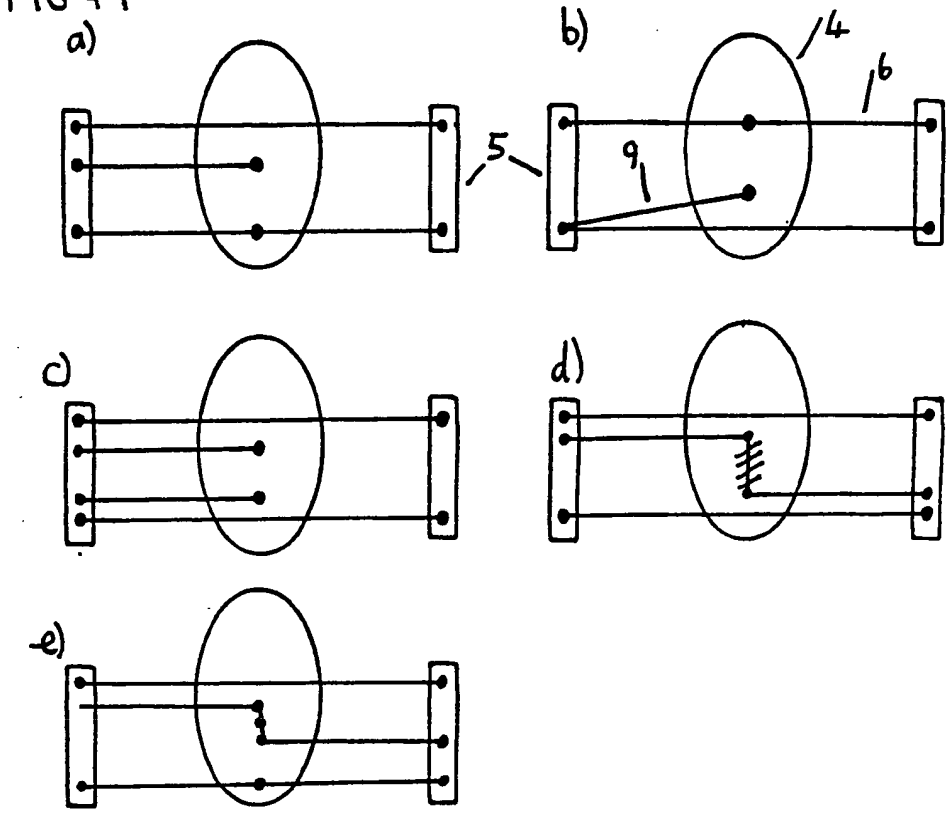


FIG 47



BANKING SUSPENSION.

2279047

TECHNICAL FIELD

This invention relates to a form of vehicular suspension which duplicates the dynamic properties of of that used in two wheeled motor and pedal cycles. It differs however in as much as it can be made inherently stable. Thus the vehicle does not fall over at low speeds or when stopped. As the rider does not need to use his feet to support the vehicle under any circumstances, it is possible for a machine employing a banking suspension to be fully enclosed, thereby allowing a vehicle to be constructed which is as safe and comfortable as a conventional motor car, and yet no bigger than a motor bike.

BACKGROUND

When one or a small number of people are to be transported, the motor bike is in many ways ideal. It can be light in weight, of high performance, offer good fuel economy etc, in addition there is a 'feel' factor, bikes are simply a pleasure to ride. For most people however the issues of personal saftey and comfort, both of which are poor on a bike, outweigh the benifits. It is possible to build enclosed or semi-enclosed motor bikes riden in a feet forwards position. Generally, as it is not possible to place either the rider or any major mechanical components alongside a wheel, these vehicles are very long for the accomodation provided. In addition fully enclosed variants require additional wheels and suspension which can be lowered to stop them falling over at low speed and when stopped. The alternative is that the rider's legs and feet perform this function, in which case the machine can only be semi-enclosed.

ESSENTIAL TECHNICAL FEATURES.

This invention relates to a form of vehicular suspension such that when a vehicle so equipped makes a turn or corners, centrifugal forces produced, dependent on the weight of the vehicle, it's speed of travel and it's cornering radius are counterbalanced by centripetal forces generated by causing the vehicle to bank, top towards the center of the turn. Thus far this is much as a bike, however, a suspension which is an embodiment of the present invention may be rotationally restrained relative to the vehicle's body, allowing the machine to be inherently stable.

According to the preferred version of the present invention a pair of wheels are disposed laterally about the body of the vehicle such that, when the vehicle is upright and set to run straight ahead, the planes perpendicular to the axes of rotation of each of the paired wheels and passing through the tyre/road contact patch (hereafter 'planes of rotation of the wheels') are substantially parallel to the vertical plane through the center of the body. If the roll constraint is removed and the vehicle is leaned without forward speed or steering movement or the vehicle is equipped with a none steering banking suspension, then the planes of rotation of the of the wheels and the 'vertical' plane through the center of the body move in unison through substantially the same angle and thus remain substantially parallel. N.B. clearly in normal use, where the banking suspension steers, the planes of rotation of the wheels will remain substantially parallel to each other within the limits imposed by the chosen steering geometry. They may not however remain parallel to the plane through the body. What will remain substantially parallel to the plane through the body are the lines joining the connections between the horizontal links and thier repective uprights. Whilst the perpendicular distance between the three planes will change as the roll angle increases, the lines of intersection of those planes with the (assumed flat) surface on which the vehicle stands will move only a little. The exact amount will depend on which embodiment of suspension geometery the vehicle uses and the fact that tyres do not form a point contact with the ground. From the point of view of the rider the vehicle's body has rotated about a substantially longitudinal line on or near to, and substantially parallel with, the ground. This is exactly what happens with a bike, thus the 'feel' of the banking suspension will be indistinguishable from a single wheel suspension. It is expected that a banking suspension will use tyres of substantially circular cross section as is current practice for motor bikes.

According another version of the present invention a pair of uprights which carry the wheels are disposed laterally about the body of the vehicle such that, when the vehicle is upright and set to run straight ahead, vertical planes through the uprights are substantially parallel to the vertical plane through the center of the body. If the roll constraint is removed and the vehicle is leaned without forward speed or steering movement or the vehicle is equipped with a none steering banking suspension, then the originally vertical planes through the uprights and the 'vertical' plane through the center of the body move in unison through substantially the same angle and thus remain

substantially parallel. It is possible to give the wheels intial positive or negative camber relative to the originally vertical planes through the uprights which will mean that the planes of rotation of the wheels and the vertical plane through the body will not be parallel when the vehicle is upright or when rolled, however when the vehicle is rolled, the angles through which the planes of rotation of the wheels and the 'vertical' plane through the body rotate will be substantially the same and in the same direction.

According another version of the present invention a pair of uprights which carry the wheels are disposed laterally about the body of the vehicle such that, when the vehicle is upright and set to run straight ahead, vertical planes through the uprights are substantially parallel to the vertical plane through the center of the body. If the roll constraint is removed and the vehicle is leaned without forward speed or steering movement or the vehicle is equipped with a none steering banking suspension, then the originally vertical planes through the uprights and the 'vertical' plane through the center of the body move in the same direction but at different rates so that the three planes may become progressively less parallel as the angle of bank increases. It is possible to give the wheels intial positive or negative camber relative to the uprights which will make the planes of rotation of the wheels even less parallel than the vertical planes through the uprights.

The two 'other' versions are not ideal. They will usually produce a change of track when the vehicle rolls causing the tyres to fight one another, which may make the machine hard to place on the road, in addition the apparent roll center from the point of view of the driver may shift harming the feel of the machine, they are not ideal versions to build, they are included for completeness.

The methods of achieving the preferred and first other version are many fold and mostly involve parallelogram or substantially parallelogram linkages. The simplist method, if the wheels are not to steer, is to rotatably connect two points on each of the wheel uprights that lie on or near the 'plane of rotation of the wheel ' (the vertical plane through the upright in the first 'other' version) by two horizontal, parallel, equal (or near equal) length horizontal links(unequal in the case of the second 'other' version) with pivots whose axes are substantialy longitudinal to the vehicle. If the wheels are to steer, the upright to horizontal link's connections may be spherical joints so that the whole upright may swivel or the connections may be pivots whose axes are for preference substantially longitudinal to the vehicle, kingpins mounted on the uprights carry the wheels and allow steering. The body is attached at or near the mid points of the horizontal links. If required, linkages and springing medium to absorb surface irregularities, are provided either, between the uprights and wheels and/or between the horizontal links and the body. Cleary the horizontal links may be in two halves, each running from the body pivot to the wheel's upright, in this case the suspension movement to absorb surface irregularities is most readily provided by allowing relative rotation of the half horizontal links about the horizontal link to body connections and resisting that rotation without reference to the vehicle's body.

Another method, hereafter termed a 'mono link' is to use a single upright to upright one piece horizontal link or two body to upright half length horizontal links, where the angular dispositions of the 'planes of rotation of the wheels' and body's 'vertical' center plane, relative to the horizontal link(s) are controlled by other means, eg. cables, gears, hydraulic, pnuematic or electrical devices etc.. It is expected that at normal road speeds the balance and degree of roll of the vehicle will be controlled by the driver using the gyroscopic properties of the steered wheel(s). This patent includes the use of systems that sense comering related parameters and use them to control the angle of bank.

It is expected that there will be some method of limiting the maximum roll angle of the vehicle, either within the suspension, or more simply, by fitting small wheels on sides of the body at the points of first contact with the surface travelled on.

NOTES ON THE PRESENTATION OF THE INVENTION.

As this patent outlines a new species of road vehicle, it is not suprising that there are miriads of possible practical, and not so practical embodiments. It is not possible to detail every permutation of geometry and physical form. Therefore the approach adopted is to break the invention down into functional elements and show the possible variations of those elements. Thus the description is stated to cover all permutions of the variations of the elements detailed.

Intially there is an overview of vehicle layouts, then the geometry of the invention is considered and finally the physical embodiments of the invention are presented.

EMBODIMENTS OF THE INVENTION :

AN OVERVIEW OF THE GENERAL LAYOUT OF VEHICLES PRODUCED ACCORDING TO THE INVENTION.

According to an embodiment of the present invention there is provided a three wheeled vehicle comprising a single front wheel, a pair of rear wheels which are those of a banking suspension , a body which provides the connecting means for the front and rear suspensions as well as accomodating the rider and other none suspension components. This layout is illustrated in FIG 1a).

According to another embodiment of the present invention there is provided a three wheeled vehicle comprising a pair of front wheels which are those of a banking suspension , a single rear wheel, a body which provides the connecting means for the front and rear suspensions as well as accomodating the rider and other none suspension components. This layout is illustrated in FIG 1b).

According to another embodiment of the present invention there is provided a four wheeled vehicle comprising a pair of front wheels which are those of a banking suspension , a pair of rear wheels which are those of another banking suspension, a body which provides the connecting means for the front and rear suspensions as well as accomodating the rider and other none suspension components. This layout is illustrated in FIG 1 c).

According to the embodiments of the present invention shown in FIGS 1a) to c) inclusive, for preference, the paired wheels are disposed about the body with lateral and longitudinal symetry. However lateral and /or longitudinal asymetry are possible. This may be minor, due to the physical/geometerical embodiment chosen or as shown in FIGS d) & e) gross and deliberate.

AN OVERVIEW OF THE GEOMETRIES OF BANKING SUSPENSIONS PRODUCED ACCORDING TO THE INVENTION.

The following paragraphs deal with the possible geometries of the suspension. The section "Essential Techical Features" covered the general requirements.

Horizontal links are provided which constrain the movement of the laterally disposed pair of uprights which carry the wheels and the movement of the body. Pivots, whose axes are, for preference, substantially parallel to the longitudinal axis of the body and on or close to the center line of the body, rotatably connect the horizontal links either directly or via a surface irregularity absorbing linkage to the body.

Where the wheels do not steer then pivots, whose axes are for preference substantially parallel to the longitudinal axis of the body and on or close to the plane of rotation of the wheels, rotatably connect the horizontal links directly to the uprights. The wheels are attatched either directly or via a surface irregularity absorbing linkage to the uprights. Or spherical joints for preference on, or close to the plane of rotation of the wheels, spherically rotatably connect the horizontal links to the uprights to which are connected (either directly or via an irregularity absorbing linkage) to the wheels, means must be provided to eliminate unwanted degrees of freedom of the uprights eg a drag link connected to the body. It would also be possible to use one axial pivot and one spherical joint.

Where the wheels steer then either pivots, whose axes are for preference substantially parallel to the longitudinal axis of the body and on or close to the plane of rotation of the wheels, rotatably connect the horizontal links to the uprights to which are connected directly or via an irregularity absorbing linkage, the king pins. The wheels are attatched either directly or via an irregularity absorbing linkage to the kingpins. Or spherical joints on, or close to the plane of rotation of the wheels, spherically rotatably connect the horizontal links to the uprights to which are connected (either directly or via an irregularity absorbing linkage) to the wheels.

It is understood that any or all of the above connections may be capable displacement under load (I.e. possess compliance) to modify the banking suspension's characteristics.

Where the horizontal links are continuous from upright to upright, and of unequal length, then, as the ratio of distance between connections on the horizontal links changes as the vehicle banks, at least one of the pivots on the body center line (be these connected directly to the body or to a subframe) must be able to move along or close to the line or extended line joining them, or at least one of the horizontal link to upright connections must be able to move along the line or the extended

line joining them on at least one upright, or at least one of the horizontal links must be able to flex in the appropriate manner,

Where the horizontal links are in two parts ie. from body to upright,and of unequal length, then rotation of the half links relative to each other absorbs this distance variation.

FIG 2 a), b) & c) show views of preferred forms of the banking suspension looking along the longitudinal axis of the vehicle with the vehicle upright and running in a straight line.

A preferred geometry of the present invention is shown in FIG 2 a). In this instance lines through the upright to horizontal link connections pass through or near to the wheel's center and extend down to points at or near the tyre's contact patch.

The effects of a surface irregularity on a banking suspension where the horizontal links are continuous from upright to upright is shown in FIG 2 a) (n.b. there is a slight narrowing of the effective track).

The effects of a surface irregularity on a banking suspension where the horizontal links are in two parts, from body to upright, is shown in FIG 2 c) (n.b. there is a slight narrowing of the effective track).

When a vehicle as described in FIG 2 a) is banked into a turn, it's geometry is as shown in FIG 2 d).

N.B. The term horizontal links is a convenience, the links can of course be cranked when seen from the front. The body/horizontal link connections may be higher or lower than the upright/ horizontal link connections, neither have to be laterally symeterical. What matters is that straight lines joining the connection points between the horizontal links and the body and the horizontal links and the uprights on each side, shall substantially approximate to, or be, a parallelogram FIG 2e. FIG 2 f) shows some extreme (and unlikely) links.

A DETAILED VIEW OF THE GEOMETRIES OF HORIZONTAL LINK TO WHEEL UPRIGHT CONNECTIONS ACCORDING TO THE PRESENT INVENTION.

VIEWED FROM HEAD ON.

There are several variations of horizontal link 6 to upright 8 connection. For convenience only links whose rotatable connections to the uprights (pivots) are disposed in the plane of rotation of the wheel 3 will be illustrated. These are shown in FIG 3, (in some embodiments, the axial pivots in a) to h) below may take the form of a spherical joint.)

FIG 3 a) Both pivots above the wheel 3.
FIG 3 b) One pivot above the wheel 3 one pivot on or near the wheel's axis of rotation.
FIG 3 c) One pivot above the wheel 3 one pivot above the wheel's axis of rotation.
FIG 3 d) One pivot above the wheel 3 one pivot below the wheel's axis of rotation.
FIG 3 e) Both pivots within the wheel 3, both above pivots above the wheel's axis of rotation.
FIG 3 f) Both pivots within the wheel 3, both above pivots below the wheel's axis of rotation.
FIG 3 g) Both pivots within the wheel 3, one pivot above, one pivot below, the wheel's axis of rotation.
FIG 3 h) Both pivots within the wheel 3, one pivot above, one pivot on, the wheel's axis of rotation.
FIG 3 i) Both pivots within the wheel 3, one pivot below, one pivot on, the wheel's axis of rotation.

It should be noted that where banking suspensions are emploied which use a kingpin, the kingpin's axis of rotation may be aligned with the horizontal link to upright connections of each upright or may follow any arbitry line.

There are also mono link banking suspensions in which other means are provided to control the relative angular positions of the 'vertical' central plane of the body, and the 'plane of rotation of the wheels'(or vertical planes through the uprights). The geometries of these are illustrated in FIG 4. Mono tubes may be in one piece running from upright to upright or two parts running from body to wheel. For convenience only links whose connections to the uprights are disposed in the plane of rotation of the wheel 3 will be illustrated.

FIG 4 a) Mono link connects to upright 8 above the wheel .
FIG 4 b) Mono link connects to upright 8 within wheel 3, above the axis of rotation of the wheel.
FIG 4 c) Mono link connects to upright 8 within wheel 3, below the axis of rotation of the wheel.

FIG 4 d) Mono link connects to upright 8 within wheel 3, on the axis of rotation of the wheel.

The horizontal links do not have to connect to the uprights on the plane of rotation of the wheel 3. FIG 5 shows the range of possible dispositions of the connections about the plane of the center of the wheel. These horizontal dispositions be applied to any of the upright to horizontal link connections shown in FIG 3. The Key to FIG 5's subsets is as follows
FIG 5 a) Zero kingpin, pure offset
FIG 5 b) zero kingpin, pure inset
FIG 5 c) zero kingpin, no inset/offset.
FIG 5 d) e) f) g) h) Negative camber, variations.
FIG 5 i) j) k) l) m) Positive camber, variations.

It should be noted that where mono-tube suspensions are emploied which use a kingpin, the kingpin's axis of rotation any arbitry line.

Each wheel may have static positive or negative camber when the vehicle is upright. This is illustrated in FIG 6 a) positive FIG 6 b) negative & FIG 6 c) mixed. Also the wheels may have static toe in or toe out when the vehicle is upright. This is is not illustrated.

Finally, with respect to wheel geometry there is the question of trail and castor. FIG 7 illustrates the characteristics of a) pure lead, b) zero lead/trail c) pure trail each of a), b), c) may be combined with d) negative castor and e) positive castor.

There is no requirement for the geometries to be laterally symeterical.

There are several variations of position of horizontal link to body connections. These are illustrated in FIG 8 n.b. uprights are omitted.
FIG 8a) Simple connections for use where the horizontal links 6 are in one piece and run from upright to upright.
FIG 8b) Co-linear (possibly co-axial) connections for, use where the horizontal links are in two parts and run from body to upright.
FIG 8c) Laterally disposed connections where the horizontal links do not cross, for use where the horizontal links are in two parts and run from body to upright (shown here symeterically disposed about the center line, although the disposition does not have to be symeterical horizontally or vertically about the center line, spaceing of top and bottom links does not have to be the same, and all links may connect entirely on one side of the body's center line)
FIG 8d) Laterally disposed connections where the links cross for use where the horizontal links are in two parts and run from body to upright, (shown here symeterically disposed about the body center line, although the disposition does not have to be symeterical about the center line, spaceing of top and bottom links does not have to be the same, and all links may connect entirely on one side of the body's center line) Clearly the links must be arranged so they do not foul each other when in operation.
FIG 8e) Vertically disposed connections for use where the horizontal links are in two parts and run from body to upright.(shown here disposed on the center line, although the disposition does not have to be vertically or laterally symeterical, or on the center line. The links to one upright may connect above and below the links to the other upright or may connect on the 'wrong' side of the center line,ie cross or may connect at essentially random positions)
N.B.The diagrams above show top and bottom links of the same type, however, any of the top body to horizontal link connections may be used in conjunction with any of the bottom body to horizontal link connections. The top and bottom links may be connected to the body by different forms of irregularity absobing linkage eg top link utilising a slider, bottom link utilising a wishbone. These geometries may also be applied to a subframe which itself connects to the body via an irregularity absorbing linkage.

FIG 9 shows the mono link to body connection.
FIG 9 a) Single connection to the body or an irregularity absorbing linkage, for use where the mono link runs from upright to upright.
FIG 9 b) Co-linear (or possibly co-axial) connections for use with two part mono links where the half mono links runs from body to upright, the body to half mono link connections do not have to be on body's center line.

FIG 9 c) Laterally disposed connections for use with two part mono links where the two half mono links run from body to upright, where the mono links do not cross, (shown here symeterically disposed about the body center line, although the disposition does not have to be symeterical horizontally or vertically about the center line, and both mono links may connect entirely on one side of the center line)
FIG 9 d) Laterally disposed connections for use where the mono link is in two parts running from body to upright where the links cross, (shown here symeterically disposed about the body center line, although the disposition does not have to be symeterical about the center line and may be entirely on one side of the center line). Clearly the mono links must be arranged so they do not foul each other when in operation.
FIG 9 e) Vertically disposed connections for use where the mono link is in two parts running from body to upright, (shown here disposed on the center line, although the disposition does not have to be vertically symeterical, or on the center line.

There is also the question of the orientation of the axes of the body to horizontal link connections in the for preference vertical longitudinal plane through their point of contact with the body FIG 10 shows some examples as applied to the front of the vehicle. Clearly these may be horizontal, point down to the front or point up to the front, be parallel or none parallel and do not have lie within the vertical longitudinal plane or be parallel to it.

Where wishbones form an irregularity absorbing linkage between body and horizontal links (with or without subframe) the initial (undisplaced) lines of the wishbones may be parallel, horizontal, angled to the horizontal or none parallel, may have an anti dive/squat geometry and may be of unequal length. The axis of rotation of horizontal link to wishbone connections does not have to be in the plane of the wishbone. It should be noted that connections with the body of either horizontal links or wishbones do not have to be aligned vertically one above the other.

Where sliders form an irregularity absorbing linkage between body and horizontal links (with or without subframe) the initial (undisplaced) axis of a pivot connection to a slider may have the same orientations as the body to horizontal link connections. Sliders may carry a subframe to which both links attatch or each link may be connected to it's own individual slider. It should be noted that sliders may be arranged to follow none linear paths and where two are involved, do not have to be aligned vertically one above the other or follow parallel paths.

In the above descriptions of banking suspension it has been assumed that where connections of upright and body to the horizontal links or mono links are rotatable about an axis, that the axis is longitudinal to the vehicle when viewed from above. This does not have to be so. Where all the connections to a horizontal link or mono link are axial then they will preferably be mutually parallel. Where there is more than one horizontal link or mono link the axial connections to each link do not need to be parallel. FIG11 shows plan views of some examples.

THE PHYSICAL EMBODIMENTS OF THE INVENTION.

It is now intended to describe the physical embodiments of the present invention.

There are three major variations of upright to horizontal link connections :

a) Where the wheels are required to steer. In this case the uprights connect to the horizontal links either by spherical joints FIG 12 a) such that the whole upright may swivel, or FIG 12 b) the uprights connect to the horizontal links via pivots whose axes are for preference substantially parallel to the longitudinal axis of the body (or are for preference parallel to the axis of the body to horizontal link connection) and thus the uprights have substantially zero rotation about the line joining the two upright to horizontal link connections. In this case the wheel's axle is mounted on a kingpin whose axis may be oriented arbitrarily relative to the line joining the two upright to horizontal link connections. Controlled compliance in the pivots, with or without extra links may be used to vary toe in/out.
b) Where the wheels do not steer. In this case the uprights connect to the horizontal links either : By spherical joints plus at least one additional retaining link (or other means FIG 12 c)) such that the whole upright may not swivel significantly about the line joining the spherical joints or will do so in a very limited range for the purpose of (presumably) better handling (an example would be to induce toe in on the wheels in roll so as to control under/over steer.

Or the uprights connect to the horizontal links via pivots whose axes are for preference substantially parallel to the longitudinal axis of the body FIG 12 d) and thus have substantially zero

rotation about the line joining the two upright to horizontal link connections. In this case the wheels are mounted on axles mounted on the uprights. Again controlled compliance in the pivots, with or without extra links may be used to vary toe in/out.
c) Where one longitudinal pivot is able to absorb the braking/acceleration torques and other forces that occour between the horizontal link and it's the upright, the remaining minor upright to horizontal link connection may be a spherical joint FIG 12 e). It should also be noted that the minor horizontal link's connection to the body, or intervening subframe, may also be a spherical joint. The upright could connect to the wheel via a kingpin FIG 12 f), or the kingpin could be the connection between the upright to major horizontal link connection and the minor horizontal link connection FIG 12 g).

There are two major variations of upright to mono link connections :

a) Where the wheels are required to steer. In this case the upright connects to the mono link via at least one axial pivot whose axis is for preference substantially parallel to the longitudinal axis of the body (or is for preference parallel to the axis of the body to horiziontal link connection) and thus the uprights have substantially zero ability to swivel about the line joining the upright to horizontal link connections on each upright. In this case FIG 13 a) the wheel's axle is mounted on a kingpin whose axis may be oriented arbitrarily. Controlled compliance in the pivots, with or without extra links may be used to vary toe in/out.
b) Where the wheels do not steer. In this case the upright connects to the mono link via at least one axial pivot whose axis is for preference substantially parallel to the longitudinal axis of the body (or is parallel to the axis of the body to horiziontal link connection) and thus the uprights have substantially zero rotation about the line joining the two upright to horizontal link connections. In this case FIG 13 b) the wheel's axle is mounted directly to the upright or on a kingpin FIG 13 c) whose axis may be oriented arbitrarily and whose rotation is controlled by other means e.g. a drag link connected to the body or the mono link. Controlled compliance in the pivots, with or without extra links may be used to vary toe in/out.
In some embodiments the irregularity absorbing linkage is provided between the wheels and the uprights, this may take many forms, including sliding pillar FIG 14a) and leading/trailing link FIG 14 b) shows a leading/ trailing link that does not steer, FIG 14 c) shows a leading/trailing link that does steer.

GENERAL POINTS ON SPRINGING MEDIA AS APPLIED TO THE CURRENT INVENTION.

The term springing medium is taken to mean any system or component that may be connected between two points or surface areas and will resist and/or control/damp relative movement, including relative rotation, between those two points. eg coil spring and damper, rubber block, hydraulic, pnuematic and magnetic systems etc. It is also envisiged that the front and rear systems may be interlinked by a means that transfers force between the two (or more) irregularity absorbing linkages of the vehicle) eg an hydraulic interlink, or an interlink may be achieved by a system that uses information and power systems to give the same effect eg active suspension.

N.b. The term irregularity absorbing linkage is used here to describe that part of the suspension whose purpose is to protect the vehicle and it's ocupants from shock loads imposed by running the vehicle on an irregular surface. It may comprise a set of components for this specific purpose or it may exist as a side effect of the physical embodiment of the banking suspension chosen.

There are four catagories of use of springing mediums which apply equally well to mono links.

1) Where the medium acts between the body or an extension thereof and either :
a) One or both of the horizontal (split or otherwise) links or an extension thereof.
b) A part of a surface irregularity absorbing linkage which intervenes between the body and the horizontal links or an extension thereof.
c) An 'extra' member or system of members which acts between either of the two parts above and the springing medium.

2) Where the medium acts between the wheel's axle or an extension thereof or part of the upright mounted irregularity absorbing linkage and the upright or an extension thereof

It should be noted that where the springing medium acts between the vehicle's body or an extension thereof and the horizontal links directly or via a surface irregularity absorbing linkage, or acts between an upright and the wheel via a surface irregularity absorbing linkage ie 1) & 2) above, the springing medium carries a proportion of the centripetal forces generated by banking into a turn and thus is compressed/twisted as the machine rolls. This makes this use of the springing medium suitable where a banking suspension is used in conjunction with a single wheel bike type suspension.

3) Where the springing medium acts between a body to horizontal link connection pivot or an extension thereof and a horizontal link or an extension thereof, or the springing medium acts between at least two of the horizontal links without reference to the body, in these cases, the springing medium rotates about the body in unison with the horizontal links(split or other wise).

4) Where the springing medium(media) act between at least two horizontal links and at least one extra member which pivots on the body but does not exert a torque on the body in normal use. (The extra member to body pivots are ideal places to apply the roll restraint).

In cases 3) and 4) it is believed by the author that the springing medium does not carry any of the centripetal forces generated by banking into a turn and thus is not additionally compressed as the machine rolls. This makes the method suitable where a banking suspension is used at both ends of a vehicle. When used in conjunction with a single wheel bike type suspension some degree of pitch may be expected in cornering with the single wheel end being lowered.

GENERAL POINTS ON THE TERM ROTATIONAL RESTRAINTS AS APPLIED TO THE CURRENT INVENTION.

These points apply equally well to mono links.

A banking suspension may be restrained in roll by forming a temporary irrotatable connection between the body or an extension thereof or a part of an irregularity absorbing linkage that is irrotatable relative to the body about the (for preference) longitudinal axis of the vehicle AND at least one of the horizontal links or a part of the irregularity absorbing linkage that is irrotatable relative to at least one of the horizontal links about the (for preference) longitudinal axis of the vehicle OR the extra member where the springing medium(media) act between the at least two horizontal links and at least one extra member which is rotatably connected to the body but does not exert a significant torque on the body in normal use.

The temporary irrotatable connection may be rigid or be displaceable under torque such that the vehicle will exhibit 'normal' (car like) roll when cornered. The actual restraint will probably follow known practice. eg friction brake and will probably be under driver control, although automatic activation, possibly in conjuction with automatic centering (possibly rendering vertical) of the banking suspension is not precluded.

BANKING SUSPENSIONS THAT UTILISE CONTINUOUS UPRIGHT TO UPRIGHT HORIZONTAL LINKS, WHERE THE HORIZONTAL LINKS ARE STRAIGHT.

N.B. In the context of the present invention the word 'straight' when refered to horizontal links is taken to mean that a line joining the two upright to horizontal link connections and the body to horizontal link (or intervening irregularity absorbing linkage to horizontal link) connection, when viewed from above is substantially straight. Usually this line will be substantially perpendicular to the body's longitudinal axis but it does not have to be. Usually the axes of the connection pivots (where used) will be perpendicular to this line and parallel to each other, but they do not have to be. The links themselves may be of any arbitry shape when viewed from above. The line between the connection points when viewed from the front/back does not have to be straight.

According to an embodiment of the present invention a banking suspension may comprise : two straight continuous horizontal links each of which connects to the uprights and is rotatably connected directly to the body FIG 15. In this case surface irregularity absorbing linkages, if provided, will be between the uprights and the wheel axles and could follow standard automotive practice. Typical examples would be sliding pillar or leading/trailling link(s) see FIG 14. Where the top and bottom horizontal links are of unequal length the ratio of distance between the pairs of connecting points will change as the vehicle rolls, this movement must be accomodated, either by allowing at least one

body to horizontal link pivot to move, or by allowing at least one horizontal link to upright pivot to move, or by making at least one horizontal link flexible in the correct plane. Otherwise something will break or there will be resistance to roll.

According to another embodiment of the present invention a banking suspension may comprise : two straight continuous horizontal links that rotatably connect to the uprights and are individually rotatably connected to an irregularity absorbing linkage that itself connects to the body. In this instance that linkage is a pair of wishbones. The wishbones are (for preference) arranged to pivot about the body in a plane substantially perpendicular to the vertical plane through the center of the body. The wishbones may be of equal or unequal length, parallel or non- parallel as required. The layout is illustrated in FIG 16 .The connections of the wishbones to the horizontal links may take several different forms.

FIG16 a) shows where the connection comprises a pivot whose axis is (for preference) substantially longitudinal to and substantially in the plane of, the wishbone. This has the effect of rotating the horizontal links as the wishbones move up and down. The method is therefore only suited to a horizontal link where the upright to horizontal link connection is via a spherical joint or other means is provided to absorb the twist induced.

FIG16 b) shows where the connection comprises a pivot whose axis is(for preference) substantially longitudinal to and substantially in the plane of, the wishbone, where another pivot is provided whose axis is (for preference) substantially parallel to that of the body to wishbone pivot and the horizontal link. This later pivot connects to the first pivot and rotatably connects to the horizontal link. The horizontal link is not allowed to move axially with respect to the second pivot. This arrangement does not rotate the horizontal links as the wishbones move up and down. The method is therefore suited to any form of horizontal link to upright connection.

FIG16 c) shows where the connection comprises two pivots of the function described for FIG 29b). But applied in reverse order. A pivot whose axis is (for preference) substantially parallel to the axis of the body to wishbone connection is attatched at the wishbone's tip. A second pivot connects to the first such that it's axis is (for preference) perpendicular to the first and substantially horizontal. This later pivot connects the horizontal link and the first pivot. The first pivot is not allowed to move axially with respect to the wishbone. This has the effect of absorbing the rotation of the horizontal links as the wishbones move up and down. The method is therefore suited to any form of horizontal link to upright connection.

FIG 16 d) shows where the horizontal link's central connections are made to a subframe. The body to subframe irregularity absorbing linkage comprises a pair of wishbone on the tip of each is a pivot whose axis is (for preference) substantially parallel to the axis of rotation of the wishbone relative to the body. The subframe is attatched to these pivots.

FIG 16 e) shows where the connection comprises a single wishbone and one extra member. A pivot whose axis is (for preference) substantially perpendicular to the axis of rotation of the wishbone is attatched at the wishbone's tip. A subframe is attatched to the pivot. The subframe carries the horizontal links. A subsiduary link is provided between the body and the subframe to control the angular relationship of the body and the subframe.

According to another embodiment of the present invention a banking suspension may comprise : two straight continuous horizontal links that connect to the uprights and are rotatably connected to the body via a surface irregularity absorbing linkage. FIG 16 f) shows where the irregularity absorbing linkage comprises a single wishbone which is arranged to pivot about about (for preference) an axis substantially perpendicular to the vertical plane through the center of the body. A subframe is rigidly attatched to the wishbone at or near it's tip. The subframe carries the horizontal links, alternatively this may be viewed as a subframe extended rearwards/forewards and pivoted on the body. Although the wishbones illustrated are all leading they could be trailing or acting as a watts linkage. FIG18 a) b) & c) respectivly.

N.B. In the above examples the wishbones may be of arbitry shape when viewed in plan. It is possible to make the wishbones substantially 'U' shaped in plan such that the space within the wishbones may be occupied by other items, eg the riders feet see FIG 17. Any of the horizontal link connections described FIG 16 a), b), c) may be used in conjunction with any other. If the pivots between a single horizontal link and it's wishbone in FIG 16 a),b),c) or between the horizontal link and the subframe FIG 16 d),e),f) are sufficiently strong and that horizontal link's connections with the uprights are axial pivots, again of sufficient strength, then any or all of the other horizontal links connections may be spherical joints.

According to another embodiment of the present invention a banking suspension may comprise : two straight continuous horizontal links that rotatably connect to a surface irregularity absorbing linkage that itself connects to the body, plus uprights and associated components. In this case the irregularity absorbing linkage comprises at least one slider. The slider may carry a subframe which itself carries both of the central horizontal link connections as illustrated in FIG 19 a) or may comprise two sliders each of which connects to a horizontal link FIG 19 b). Clearly, at least one slider must not rotate perpendicular to it's line of movement. It is also clear that where there are two sliders and thier movement is not linear and parallel then they are analogous to the tips of wishbones and the variations of pivot arrangements required to absorb relative rotation of the horizontal links described for the tips of wishbones (FIG 16) may be applied here. The slider(s) do(es) not have to move in a straight line when viewed from the side or front or top nor do they have to stay, or ever be, in the 'vertical' central plane of the body FIG 19 c). It is possible to use a slide and a wishbone within the same surface irregularity absorbing linkage see FIG 19 d).

According to another embodiment of the present invention a banking suspension may comprise : two straight continuous horizontal links that rotatably connect to the body and to the uprights plus associated components, where both of the horizontal links comprise single or multi leaf leaf springs. Clearly there will be additional components required to provide damping of the banking suspension. FIG 20 a) illustrates.

According to another embodiment of the present invention a banking suspension may comprise : two straight continuous horizontal links one of which rotatably connects to the body or an extension thereof and comprises single or multi leaf leaf spring, whilst the other is inflexible and connects to the body via an irregularity absorbing linkage that allows the center of the second horizontal link to move vertically relative to the body, plus uprights and associated components. FIG 20 b) illustrates the use of a wishbone.

According to another embodiment of the present invention a banking suspension may comprise : a straight continuous horizontal link which rotatably connects to the body or an extension thereof and comprises single or multi leaf leaf spring, a pair of half length horizontal links which rotateably connect to the body such that damping the relative rotation of the halve links will damp this movement of the whole banking suspension. FIG 20 d) illustrates the embodiment.

MOUNTING THE SPRINGING MEDIUM.

Where the irregularity absorbing linkage is of the form of slider(s) or wishbone(s) the springing medium will usually act between the body or an extension thereof and a member of the irregularity absorbing linkage.

There is special variation illustrated in FIG 21 a). Which relates to horizontal links mounted individually on wishbones. This comprises a pivot whose axis is (for preference) substantially parallel to the longitudinal axis of the body and crosses or passes close to the axis of the wishbone to body connection. At or near the crossing point the longitudinal pivot is universally connected to an extension of the horizontal link, said extension passing through a bearing at or near the tip (or in/on the body) of the wishbone. Due to the action of the universal coupling the longitudinal pivot and the horizontal link rotate in unison. The springing medium acts between an extension of the body mounted longitudinal pivot or the body mounted longitudinal pivot itself and the horizontal link or an extension thereof .

There is another special variation illustrated (in plan and with the springing medium removed for the sake of clarity) in FIG 21 b). Which relates to horizontal links mounted on a subframe which is in turn mounted on wishbones.This comprises a pivot whose axis is (for preference) substantially parallel to the longitudinal axis of the body and whose axis crosses or passes close to the axis of the wishbone to body connection. At or near the crossing/near point the longitudinal pivot is universally connected to an extra member which passes through a bearing within the wishbone, at or near the tip of the wishbone for preference at or near where the axis of the extra member intersects the axis of the pivot whose axis is parallel to the body to wishbone pivot said extra member is universally connected to an extension of the horizontal link which passes through the subframe and may also provide the horizontal links pivot within the subframe. Due to the action of the universal couplings and the extra member the longitudinal pivot and the horizontal link rotate in unison. The springing medium acts between an extension of the body mounted longitudinal pivot or the pivot itself and the extra member or the horizontal link or an extension thereof .

BANKING SUSPENSIONS THAT UTILISE CONTINUOUS UPRIGHT TO UPRIGHT HORIZONTAL LINKS WHERE THE HORIZONTAL LINKS ARE CRANKED AND DO NOT RC·TATE ABOUT THE AXES OF THIER CENTRAL PORTIONS.

In the context of this document the term 'cranked horizontal links', is taken to mean horizontal links where, when viewed from above, the upright and body connection points on the link are not in a straight line. For preference the horizontal links are substantially 'U' shaped, 'Z' shaped horizontal links or horizontal links of arbitrary shape, are not, however, precluded. When viewed from the front/rear the connection points may or may not lie on a straight line.
A benifit of cranked horizontal links is they they can improve the utilisation of a vehicles internal space.

According to another embodiment of the present invention a banking suspension may comprise a pair of cranked, continuous upright to upright links plus the uprights, wheels and other associated componentry there are several variations described and illustrated below.

FIG 22 a) shows cranked horizontal links which connect directly to the body and where the irregularity absorbing linkage, if any is provided on the uprights.
FIG 22 b) shows FIG22 a) in plan view where the wheels are to steer. The feet illustrate one use for the space now avaliable.
FIG 22 c) shows FIG22 a) in plan view where the wheels do not steer, note the effect on the permissable degree of crank.

Cranked horizontal links may be mounted on a subframe and that subframe may be mounted on wishbones, slides or be an extended, pivoted subframe. Points made earlier about the mounting of subframes apply in these instances also.

Cranked horizontal links may be seperatly mounted on individual wishbones or slides, in these cases the distance between the center connections of the horizontal links must be held substantially constant (x on FIG 23) (which could be achieved by using axial pivots for the horizontal link to upright connections) or the geometry is indeterminant. In the caseof wishbone mounted horizontal links, it is desirable, where the crank of the horizontal links is towards the wishbones, to provide the irregularity absorbing linkage with additional mechanism so that as the wishbones rotate relative to the body, the plane of the horizontal links retains substantially it's original orientation to the road's surface,FIG 23 a) & b) which will in part require the use of wishbone tip pivots as illustrated in FIG16. If this is not done then the crank of the link effectivly shortens the wishbones. Where the crank of the horizontal links is away from the wishbones it effectivly lengthens the wishbones and no special mechanism is required.

MOUNTING THE SPRINGING MEDIUM.
Where the irregularity absorbing linkage is of the form of slider(s) or wishbone(s) the springing medium will usually act between the body or an extension thereof and a member of the irregularity absorbing linkage.
There is special variation illustrated in FIG 2 a). Which relates to horizontal links mounted individually on wishbones. This comprises a body mounted axial pivot whose axis is (for preference) substantially parallel to the longitudinal axis of the body and crosses or passes close to the axis of the wishbone to body connection. At or near the crossing point the longitudinal pivot is universally connected to an extension of the horizontal link, said extension passing through a bearing at or near the tip of (or in the body of) the wishbone. Due to the action of the universal coupling the body mounted longitudinal pivot and the horizontal link rotate in unison. The springing medium acts between an extension of the body mounted longitudinal pivot and the horizontal link or an/the extension thereof .
There is another special variation illustrated in FIG 21 b). Which relates to horizontal links mounted on a subframe which is in turn mounted on wishbones.This comprises a body mounted pivot whose axis is (for preference) substantially parallel to the longitudinal axis of the body and whose axis crosses or passes close to the axis of the wishbone to body connection. At or near the crossing point the longitudinal pivot is universally connected to an extra member which passes through a bearing within the wishbone, at or near the tip of the wishbone and for preference at or near where the extra member intersects the axis of the wishbone tip to subframe pivot, said member

is universally connected to an extension of the horizontal link which passes through the subframe and may also provide the horizontal link's pivot within the subframe. Due to the action of the universal couplings and the extra member the body mounted longitudinal pivot and the horizontal link rotate in unison. The springing medium acts between an extension of the body mounted longitudinal pivot and the extra member or the horizontal link or an extension thereof .

BANKING SUSPENSIONS THAT UTILISE CONTINUOUS UPRIGHT TO UPRIGHT HORIZONTAL LINKS WHERE THE HORIZONTAL LINKS ARE CRANKED AND ROTATE ABOUT THE AXES OF THIER CENTRAL PORTIONS.

Another benifit of cranked horizontal links is that if allowed to rotate about the axis of thier central portion they can provide an intergral surface irregularity absoption linkage. N.B. the distance between the body to horizontal link connections must be held constant or controlled or the linkage is indeterminate.

According to another embodiment of the present invention a banking suspension may comprise : a pair of cranked, continuous upright to upright horizontal links that may rotate about the axes of their central portions, plus the uprights, wheels and other associated componentry. There are several variations described below.

FIG 24 a) shows cranked horizontal links which connect directly to the body and where irregularity absorbing movement is provided by allowing the horizontal links to rotate about the axis of that portion that connects to the body. In this case the first of the two required pivots is longitudinal to the body and the second is coaxial with the axis of the central portion of the horizontal links.
FIG 24 b) shows FIG 24 a) in plan view where the wheels are to steer. The feet illustrate one use for the space now avaliable.
FIG 24 c) shows FIG 24 a) in plan view where the wheels do not steer, note the effect on the permissable degree of crank.
FIG 24d) shows cranked horizontal links which connect directly to the body and where irregularity absorbing movement is provided by allowing the horizontal links to rotate about the axis of that portion that connects to the body. In this case the first of the two required pivots is longitudinal to the body and the second is parallel to and offset from the axis of the central portion of the horizontal links.
FIG 24e) shows cranked horizontal links which connect directly to the body and where irregualrity absorbing movement is provided by allowing the horizontal links to rotate about the axis of that portion that connects to the body. In this case the first of the two required pivots is parallel to the axis of the inner portion of the horizontal links and the second is longitudinal to the body.

Cranked horizontal links that rotate about thier central portion, may be mounted on a subframe and that subframe may be mounted on wishbones FIG 24 f) in which case it would be possible to interlink the wishbones and the horizontal links so that suspension movement is shared predictably between them or such that the horizontal links retain a substantially constant orientation to the ground. Additionally although somewhat perversly, the subframe may be mounted on a slider or on an extended, pivoted subframe.

MOUNTING THE SPRINGING MEDIUM.
It is possible to simply mount the springing medium between the body or an extension thereof and an extension of the horizontal link FIG 25 a) illustrates. This will work well when the vehicle is upright but as the vehicle leans the line of action of the springing medium becomes progressivly less ideal. FIG 25 b) shows why.
It is also possible to mount the springing medium between the body or an extension thereof and an extra member pivoted on the horizontal link such that when viewed from the front/rear, it is free to rotate on the horizontal link but is retained at substantially the original orientation to the body such that the point of connection with the springing medium does not rotate perpendicular to the longitudinal axis of the vehicle. FIG 25 c) illustrates. This will work well when the vehicle is upright and as the vehicle leans the line of action of the springing medium remains acceptable. FIG 23 d) shows why.
Probably the best solution is to mount the springing medium between an extension of a horizontal link and the for preference longitudinal body to horizontal link pivot of that link or an extension

thereof or to a (possibly) connected, pivot substantally coaxial with the first longitudinal pivot, such that both mounts of the springing medium rotate in unison with the horizontal link.
FIG 25 e) f) & g) illustrate. This will give a correct line of action of the springing medium at all orientations of the vehicle.
Also the springing medium could act between the horizontal link and the pivot about which it rotates about it's own axis, FIG 25 h) illustrates the idea, where the shaded area is the springing medium in torsion.
Finally where the horizontal link is mounted on a wishbone the springing medium may be used to oppose the rotation of the horizontal link relative to the wishbone FIG 25 i). In each of the above cases the rotational restraint may act on the body/central pivot of either horizontal link.

BANKING SUSPENSIONS THAT UTILISE TWO PART HORIZONTAL LINKS THAT RUN FROM THE BODY CONNECTION TO THE UPRIGHT CONNECTION. WHERE THE HORIZONTAL LINKS ARE STRAIGHT.

The term straight with respect to two part horizontal links for preference means that a line drawn perpendicular to the half horizontal link to body connection's axis and through that connections center will pass through or near the center of the half horizontal link to upright connection.
However a looser definition applies in many cases i.e. that the horizontal link is literally straight between it's body and upright connections and does not have to be perpendicular to it's body pivot axis.
The major point of utilising split straight horizontal links is to provide irregularity absorbing movement by allowing the relative rotation of the resulting lateral pairs of horizontal links about thier body to link connections. For preference the axes of the body to half horizontal links are substantially longitudinal to the body but they do not have to be. The springing medium will act between at least one link from each side of the banking suspension probably in association with other components. An additional use for a two part horizontal link is as a replacement for one of a pair of unequal length one piece horizontal links which are attached to either the body or a subframe, relative rotation between the two split horizontal links accomodates the center distance movement that that arrangement expirences when the vehicle rolls or strikes a surface irregularity.

According to another embodiment of the present invention a banking suspension may comprise two pairs of straight upright to body horizontal links each of which may rotate about the (for preference) longitudinal axis of it's body pivot, plus the uprights, wheels and other associated componentry. There are several variations of the horizontal link to body pivot layout described and illustrated below n.b. these all show longitudinal body to horizontal link pivot axes, these axes could be otherwise. See FIG 11.

FIG 8 b), c), d), e), show the head on view of this geometry . There are variations in plan view too these are illustrated in FIG 24 using coaxial links as an example.
FIG 26 a) Assymeterical track, perpendicular links.
FIG 26 b) Symeterical track, none perpendicular links.
FIG 26 c) Uprights fore/aft of body connection, symeterical track.
FIG 26 d) Uprights fore/aft of body connection, assymeterical track
It is important to note that the above are diagramatic, the split links may be of any arbitry shape and the connections at the body may be interleaved. Examples are shown in FIG 26 e) to h). The illustrations shown are for coaxial split link to body connections. Similar principles apply to the other geometries shown in FIG 8, whilst FIG 26 i) to k) illustrates some combined geometries.

MOUNTING THE SPRINGING MEDIUM.
The methods may be broken down into two broad groups.
1) where the springing medium acts directly between at least two of the half links or extensions thereof. FIG 27 shows some possibilities.
FIG 27 a) Springing medium acting between extensions of the half links.
FIG 27 b) Springing medium acting in shear between the half links.
FIG 27 c) Springing medium rotatably connected to the body and has extensions to form the half links.
FIG 27 d) Springing medium in shear between central extensions of the half links.
FIG 27 e) Springing medium is in shear between central extensions of the half links.

2) where the springing medium acts between two of the half links or extensions thereof via an extra member pivoted on the body and possibly other links.FIG 28 shows some possibilities.
FIG 28 a) Two springing media acting between a pivoted member and two of the half links.
FIG 28 b) Springing medium acting between the half links and a bell crank pivoted coaxial with or close to the half link pivots.
FIG 28 c) Effectivly b) with the Springing media attached to the same point.
FIG 28 d) The Springing medium takes the form of a leaf spring pivoted to the body and connected via links to the the horizontal half links.
FIG 28 e) A springing medium is pivoted coaxial with or close to the horizontal half link pivots and is connected to the horizontal half links via other links.
FIG 28 f) Shows that the rotational restraint may on one end of a longitudinal pivot and the springing medium linkages on the other.
FIG 28 g) Shows that the rotational restraint may remote from the longitudinal pivot to which the springing medium linkages attatch.
N.b. the rotational restraint could act on the hatched areas in a) b) & c) above.

BANKING SUSPENSIONS THAT UTILISE TWO PART HORIZONTAL LINKS THAT RUN FROM THE BODY CONNECTION TO THE UPRIGHT CONNECTION. WHERE THE HORIZONTAL LINKS ARE CRANKED AND DO NOT ROTATE ABOUT THE AXES OF THIER INNER PORTIONS.

The term cranked two part (split) horizontal links, is taken to mean links where, when viewed from above, the upright and body connection points are not in the plane perpendicular to the axis of and through the center of the body to half horizontal link's connection. For preference the links are substantially 'L' shaped, although the angle formed by the arms of the 'L' will typically be greater than 90 degrees. Links of arbitry shape are not precluded.
These forms are very similar to the straight two part links. The aim of utilising them is to improve the vehicle's internal space utilization at minimal extra cost.

According to another embodiment of the present invention a banking suspension may comprise two pairs of cranked, upright to body horizontal links plus the uprights, wheels and other associated components which do not rotate about the axes of there inner portions. The possible arrangements of horizontal links and use of springing media are substantially the same as for straight two piece horizontal links.

FIG 29 a) shows a perspective view of one embodiment. FIG 29 b) shows the packaging advantages available.

BANKING SUSPENSIONS THAT UTILISE TWO PART HORIZONTAL LINKS THAT RUN FROM THE BODY CONNECTION. TO THE UPRIGHT CONNECTION. WHERE THE HORIZONTAL LINKS ARE CRANKED AND ROTATE ABOUT THE AXES OF THIER INNER PORTIONS IN ORDER TO PROVIDE IRREGULARITY ABSORBING MOVEMENT.

According to another embodiment of the present invention a banking suspension may comprise two pairs of cranked, upright to body horizontal links which may rotate about the axes of thier central portions, plus the uprights, wheels and other associated components.

For clarity FIG 30 illustrates one upright to upright connection only.

FIG 30 a) shows two part cranked horizontal links which connect to the body and where irregularity absorbing movement is provided by allowing the cranked two part horizontal links to rotate about the axis of that portion that connects to the body. In this case the axis of the first of the two required pivots is (for preference) longitudinal to the body and the second (n.b. there are two of them) is (for preference) parallel to the axis of the inner portion of the horizontal links.
FIG 30 b) shows two part cranked horizontal links which connect to the body and where irregularity absorbing movement is provided by allowing the cranked two part horizontal links to rotate about the axis of that portion that connects to the body. In this case the axis of the first of the two (of which there are two) required pivots is (for preferrence) parallel to the axis of the inner portion of the link and the axis of the second pivot is (for preference) longitudinal to the body.
FIG 30 c) shows two part cranked horizontal links which connect to the body and where irregularity absorbing movement is provided by allowing the cranked two part horizontal links to rotate about the

axis of that portion that connects to the body. In this case the axis of the first of the two (of which there are two) required pivots is (for preference) longitudinal to the body and the axis of the second pivot is (for preference) parallel to or coxial with the axis of the inner portion of the link.
FIG 30 d) shows two part cranked horizontal links which connect direct to the body and where irregularity absorbing movement is provided by allowing the cranked two part horizontal links to rotate about the axis of that portion that connects to the body. In this case the axis of the first of the two (of which there are two and they are separate) required pivots is not longitudinal to the body and the axis of the second pivot is not parallel to or coxial with the axis of the inner portion of the link. This is the none orthogonal equivalent of FIG 30 a). The none orthogonal equivalents of FIG 30 a) & b) are self evident.

MOUNTING THE SPRINGING MEDIUM.

There are three broad groups of use of the springing medium.
1) Where the springing medium acts between a body to horizontal link connection pivot or extension thereof and a horizontal link or extension thereof on each side of the body.
FIG 31 a) shows one arrangement for media in compression/tension.
FIG 31 b) shows one arrangement for media in torsion (one side only shown).

2) Where the springing medium acts between two a horizontal links or extension thereof and a member pivoted on the body, or the springing medium is the pivoted member.
FIG 32 a) shows one arrangement for media in compression/tension.
FIG 32 b) shows an arrangement for where the springing medium is a leaf spring pivoted on the body and connected to extensions of the horizontal links.

3) Where the springing medium acts between a pair of horizontal links of opposed crank or extensions thereof, one on each side of the body.
FIG 33 a) shows one arrangement for media in torsion .
FIG 33 b) shows one arrangement for media in compression/tension.
FIG 33 c) shows one arrangement using a member pivoted on the body.

BANKING SUSPENSIONS THAT UTILISE ONE ONE PIECE HORIZONTAL LINK (MONO LINK) THAT RUNS FROM UPRIGHT CONNECTION TO UPRIGHT CONNECTION.

Mono link banking suspensions are those in which the main loads are absorbed by one major link whilst other means are provided to control the relative angular positions of the 'vertical' central plane of the body, and the 'plane of rotation of the wheels'. Ideally the 'other means' will fit within the 'major' link although they do not have to. It is possible to arrange the 'other means' such that the body and uprights do not roll through the same angle and/or such that the angular relation between the body and uprights is not linear. Whilst this may be done to provide better grip in corners by for example keeping the wheels parallel and banked through a lesser angle than the body, doing so may spoil the feel of the vehicle.

According to another embodiment of the present invention a banking suspension may comprise a mono link which runs from upright to upright, plus the uprights, wheels and other associated components. The surface irregularity absorbing linkage, if provided, may be between the mono link and the body, where most of the forms described for upright to upright horizontal links apply, or between the uprights and the wheels.

There are many methods by which the angular relationship of the uprights and body may be controlled. FIG 34 illustrates some of them.
FIG 34 a) A parallel single upright to upright horizontal control link or two half horizontal body to upright control links which are very close to or within the mono link. The control link(s) may be spherically connected.
FIG 34 b) Hydraulic control.
FIG 34 c) Cable or other inextensible medium control.
FIG 34 d) e) Use of bevel gears or sectors there of. Bevel gears or sectors thereof are irrotatably attatched to the body and uprights (for preference with their axes longitudinal to and coaxial with the body/upright to mono link pivot). Each of the above has a matching bevel gear or sector thereof which is irrotatably attatched to a shaft that runs from upright to upright this shaft (or there are two

shafts each of which runs from body to upright and has two bevel gears mounted irrotatably upon it) will rotate freely in bearings in/on the monolink or in bearings mounted in mounts that pivot coaxially with the matching bevel gear's axis. There are several detail variations.
FIG 34 f) & g) Use of chains or toothed belts. Sprockets or sectors thereof are irrotatably attatched to the body and uprights (for preference with their axes longitudinal to and coaxial with the body/upright to mono link pivot). Then either, a belt/chain runs from upright to upright with at least one central point attatched to the body or there are two body mounted sprockets and two belts/chains each of which run from body to upright. There are several detail variations.
FIG 34 h) Use of rack and pinion gears or sectors thereof. Gears or sectors thereof are irrotatably attatched to the body and uprights. Each of the above has a matching rack or section thereof which is attatched to or forms a rod that runs from upright to upright. The rod runs freely in bearings in the monolink or in bearings mounted in mounts that pivot coaxially with the matching pinion gear's axis The body or upright rack and pinion may be replaced by a simple for preference, longitudinal pivot or spherical joint. The control link may be in one piece from upright to upright or in two pieces from body to upright. There are several detail variations.

BANKING SUSPENSIONS THAT UTILISE TWO PIECE MONO LINKS EACH OF WHICH RUN FROM UPRIGHT CONNECTION TO BODY CONNECTION.

According to another embodiment of the present invention a banking suspension may comprise two half length mono links each of which runs from body to upright, plus the uprights, wheels and other associated components. The surface irregularity absorbing movement will be provided by allowing the relative roatation of the two mono links and controlling this using the methods outlined for two piece straight links.
There are many methods by which the angular relationship of the uprights and body may be controlled. Three of the new forms are illustrated in FIG 35 a), b) & c) it is clear by inspection how the forms refered to in d),e),f) & h) should look.
FIG 35 a) Two half horizontal body to upright control links which are very close to or within the split mono links. The control links may be spherically connected.
FIG 35 b) Hydraulic control.
FIG 35 c) Cable or other flexable inextensible medium control.
d) e) Use of bevel gears or sectors thereof. Bevel gears or sectors thereof are irrotatably attatched to the body and uprights (for preference with there axes longitudinal to and coaxial with the body/upright to horizontal link pivot). Each of the above has a matching bevel gear or sector thereof which is irrotatably attatched to a shaft that runs from upright to body, these shafts will rotate freely in bearings in the mono link or in bearings mounted in mounts that pivot coaxially with the matching bevel gear's axes. There are several detail variations.
f) g) Use of chains or toothed belts. Sprockets or sectors thereof are irrotatably attatched to the body and uprights (for preference with their axes longitudinal to and coaxial with the body/upright to mono link pivot). There are two belts/chains each of which runs from body to upright. There are several detail variations.
h) Use of rack and pinion gears or sectors thereof. Gears or sectors thereof are irrotatably attatched to the body and uprights. Each of the above has a matching rack or section thereof which is attatched to or forms a rod that runs from body to upright. The rod runs freely in bearings in the mono link or in bearings mounted in mounts that pivot coaxially with the matching pinion gear's axis The body or upright rack and pinion may be replaced by a simple for preference longitudinal pivot, the control link will be in two pieces each running from body to upright. There are several detail variations.
N.B. Clearly mono links, be they single or two part, may be cranked if required and the control method adapted to suit.

POWERING THE WHEELS OF A BANKING SUSPENSION.

According to another embodiment of the present invention at least one, but for preference both wheel(s) of a banking suspension may be driven by motors and appropriate transmission means mounted on the upright(s). These motors may be prime movers in there own right or may be driven from a power source mounted elsewhere, usually the body, in the vehicle. Examples of the first would be i.c. engines on the uprights and examples of the last would be electric motors driven by batteries or hydraulic motors driven by an i.c. engine driven pump. Clearly there are advantages to

having the power source carried in the body and using some form of transmission to carry the power to at least one of the wheels.

'BELT DRIVE'.

According to another embodiment of the present invention the transmission to drive at least one wheel of a banking suspension from a body mounted power source may comprise, a chain or toothed belt sprocket or flat or v belt pulley or other driving means rotatably mounted on the body and driven from the power source by appropriate transmission means, a chain or toothed belt sprocket or flat or v belt pulley or other driven means mounted rotatably on the upright in conjunction with a means of changing the rotation of said driven means through the angle required to drive the wheel (typically a pair of beve. gears) and the connection to the wheel, a chain, toothed, flat or v belt or other transmission means which connects the driving and driven means and methods to ensure the correct tension and location of the transmission means.

For preference the driving means will be mounted on the body coaxially with the body to horizontal link connection for one horizontal link or coaxially with the body to mono tube link connection, the driven means will be mounted on the upright coaxially with the upright to horizontal link connection for the same horizontal link or coaxially with the the upright to mono tube link connection, this arrangement gives zero change in transmisssion means length when the vehicle banks. FIG 36 a) illustrates the above for paired horizontal links, when the vehicle is upright. N.B. Wheel omitted from all FIG 36 diagrams.

Or for preference the driving means will be rotatably mounted on the body along the line joining the two body to horizontal link connections or an extension thereof or 'vertically' above/below the mono tube to body connection, the driven means will be rotatably mounted on the upright along the line joining the upright to horizontal link connections or an extension thereof in the same relative position as the driving means has to the body to horizontal link connections or the driven means will be mounted as far above/below the mono tube to upright connection the driving means was on the body. Also the axes of rotation of the driving and driven means will be longitudinal to the body and parallel to each other. This arrangement gives zero change in transmisssion means length when the vehicle banks.FIG 36 b) illustrates the above when the vehicle is upright.

Or for preference the driving means will be rotatably mounted on the body with a known offset from the line joining the two body to horizontal link connections or an extension thereof or at a known positiion relative to the mono tube to body connection, the driven means will be rotatably mounted on the upright with the same offset from the line joining the upright to horizontal link connections or an extension thereof in the same relative position as the driving means has to the body to horizontal link connections or the driven means will be mounted at the same relative position to the mono tube to upright connection as the driving means has to the body to horizontal link connection. Also the axes of rotation of the driving and driven means will be parallel but may not be longitudinal to the body. This arrangement gives zero change in transmisssion means length when the vehicle banks. FIG 36 c) illustrates the above for a mono link, when the vehicle is upright.

According to another embodiment of the present invention a transmission as described above may be utilised to drive each of the wheels of a banking suspension from a body mounted power source. This will for preference require the provision of two body mounted driven means which may be irrotatably locked together, mounted coaxially or not , driven seperatly, rotate independantly in the same or opposite sense, or be connected by a differential. FIG 37 shows a differential whose input is coaxial with a driven means and where at least one of the driven means rotates upon the input shaft.

FIG 38 a)shows a plan view of a belt drive transmission where the two driven means are rotating in the same sense.

FIG 38 b)shows a plan view of a belt drive a transmission where the two driven means are rotating in the opposite sense.

'GEAR DRIVE'.

According to another embodiment of the present invention the transmission to drive at least one wheel of a banking suspension from a body mounted power source may comprise, a driving bevel gear rotatably mounted on the body and driven from the power source by appropriate means, a second driven bevel gear rotatably mounted on the upright in conjunction with a means of changing the rotation of said second bevel gear through the angle required to drive the wheel (typically a third

bevel gear) and the connection to the wheel, a drive shaft whose length may be variable, to which are irrotatably connected a futher pair of bevel gears which are held in mesh with the body and upright mounted bevel gears.

For preference the driving bevel gear on the body will be mounted coaxially with the body to horizontal link connection for one horizontal link or the mono tube link, the driven bevel gear will be mounted on the upright coaxially with the upright to horizontal link connection for the same horizontal link or the mono tube link, the drive shaft will run in bearings located on/in the horizontal link/mono link or in bearings whose mounts pivot on or are coaxial with those of the meshing driven or driving bevel gear. This arrangement gives zero change in transmisssion means length when the vehicle banks.

FIG 39 a) illustrates the above when the vehicle is upright.

FIG 39 b) shows a plan view of the drive line using a horizontal link to mount the drive shaft.

N.B. The relative positioning of the gears is important if the wheel is not to rotate as the vehicle banks.

Or for preference the driving bevel gear will be rotatably mounted on the body along the line joining the two body to horizontal link connections or an extension thereof or 'vertically' above/below the mono tube link to body connection, the driven bevel gear will be rotatably mounted on the upright along the line joining the upright to horizontal link connections or an extension thereof in the same relative position as the driving bevel gear has to the body to horizontal link connections or the driven bevel gear will be mounted as far above/below the mono tube to upright connection the driving bevel gear was on the body. Also the axes of rotation of the driving and driven bevel gears will be longitudinal to the body. Where the driving and driven bevel gears are not coaxial with a horizontal link connection then the drive shaft will have to be mounted in bearings whose mountings pivot on or are coaxial with the axes of the driving and driven bevel gears, even so as the tolerances required of gears are very close, one of the drive gears may need to float axially along the shaft. It would be possible to use the drive shaft as a horizontal link of the suspension. This arrangement gives zero change in drive shaft length when the vehicle banks.FIG 39 c) illustrates the above when the vehicle is upright .FIG 39 d) illustrates the above when the vehicle is banked. FIG 39 e) shows a plan view of the drive line using coaxially mounted bearing mounts(n.b. horizontal links omitted for clarity).

Or for preference the driving bevel gear will be rotatably mounted on the body with a known offset from the line joining the two body to horizontal link connections or an extension thereof or at a known position relative to the mono tube link to body connection, the driven bevel gear will be rotatably mounted on the upright with the same offset from the line joining the upright to horizontal link connections or an extension thereof in the same relative position as the driving bevel gear has to the body to horizontal link connections or the driven bevel gear will be mounted at the same relative position to the mono link to upright connection as the driving has to the body to mono link connection. Also the axes of rotation of the driving and driven bevel gear may or may not be parallel and may or may not be longitudinal to the body.Where the driving and driven bevel gears are not coaxial with a horizontal link or mono link connection then the drive shaft will have to be mounted in bearings which pivot on or are coaxial with the axes of the driving and driven bevel gears, even so as the tolerances required of gears are very close at least one of the drive gears may need to float axially along the shaft. It would be possible rigidly fix the gears to the drive shaft and to use the drive shaft as a horizontal link of the banking suspension. This arrangement gives zero change in drive shaft length when the vehicle banks. N.B. If the driven and driving means do not have congruent positions then the drive shaft connecting them may need to be of variable length.

According to another embodiment of the present invention a transmission as described in 'belt drive and gear drive' above may be utilised to drive each of the wheels of a banking suspension from a body mounted power source. This will require the sharing of the body mounted bevel gear/driving means or the provision of two body mounted bevel gears/driving means which may be irrotatably locked together, mounted coaxially or not, driven seperatly, rotate independantly in the same or opposite sense, or be connected by a differential.

STEERING THE DRIVEN WHEELS.

It is entirely possible to steer driven wheels, this may be done to give a compact front wheel drive package or to allow four wheel steering.

According to another embodiment of the present invention a wheel driven by one of the above means may also steer. To allow this there must be additional components provided on the upright, these shall comprise, a swivel or kingpin mounted upon the upright which shall carry the axle and it's wheel, a universal joint which shall connect the output of the drive means (usually the bevel gear mounted on the upright whose axis of rotation is for preference substantially parallel to the axis of rotation of the wheel when the vehicle is running straight ahead) to the wheel.
FIG 40 a) illustrates one of the many possibilties, note that the steering axis may be independant of the line joining horizontal to upright links.
FIG 40 b) illustrates one of the many possibilties in conjunction with a mono link, note that the steering axis may be independant of the mono link geometry.

According to another embodiment of the present invention a wheel driven by an adaptation of 'gear drive' above may also steer. To allow this there must be additional componants provided on the upright, these shall comprise, an upright which may swivel (is mounted on ball joints) and carries the wheel, a bevel gear whose axis is coaxial with the wheel, a second bevel gear meshing with the first, a third bevel gear meshing with the second and which is universally joined to the, possibly variable length, drive shaft.
FIG 41 illustrates one of the many possibilties, note that the steering axis is the line joining horizontal link to upright connections.

STEERING GEOMETRY OF A BANKING SUSPENSION.

When the vehicle is upright and rotationally locked the steering geometry requirements are strongly analogous to those of a 'normal' double wishbone suspension (or solid axle or swing arms in the case of mono links). The geometry may be parallel, ackerman, anti ackerman or of any other form. As a general guide the steering geometry will need to mimic the banking suspension geometry but be moved fore or aft of the banking suspension in order to swivel the wheels. It will be possible to alter the relative steering angles of the wheels as the vehicle is rolled if that is desired.

VARIATIONS ON THE FRINGE OF UTILITY.

N.B. Most of the following apply equally well to mono links.

1) Where wheels of small diameter are required there may not be enough room to accomodate the required components within the wheel. FIG 42 shows how this may be achieved.
FIG 42 a) shows the wheel mounted on a fore/aft extension of the upright.
FIG 42 b) shows the wheel mounted on an extended upright which connects to two sets of horizontal links.
It would be possible to attatch the extended upright to two sets of interconnected horizontal links, this would be a more mechanically acceptable arrangement.
FIG 42 c) shows an extended upright.
FIG 42 d) shows one of the interconnected horizontal links.
FIG 42 e) shows a complete unit in perspective.
The idea may be adapted to work with mono links too.

2) The vehicle's body may be raised above the level of the wheels by extending it well above the body to horizontal link connections. This would allow the bulk of the vehicle to be high above the ground which may improve the vehicle's aerodynamics and allow the wheels to be mounted in a ground effect pod. The idea may be adapted to work with mono links too.
FIG 43a) & b) show the idea in conjunction with 1) above.

3) Other ways to raise the body are illustrated in
FIG 44 a) by raising the body to horizontal link connection points relative to those of the upright to horizontal link connections.
FIG 44 b) by raising the body to horizontal link connection points relative to those of the upright to horizontal link connections and extending the body upwards.
FIG 44 c) by placing the upright to horizontal link connections above the wheels and connecting the body to the horizontal links at the same height. This minimises the effect of the ground on the vehicle.

FIG 44d) by placing the upright to horizontal link connections above the wheels and extending the body to the horizontal links upwards. This minimises the effect of the ground on the vehicle. The idea may be adapted to work with mono links too.

4) As when it is banked a vehicle equipped with a banking suspension has a means of 'knowing' what is horizontal it may be possible to exploit aerodynamic down force in a way that a motor bike may not. This would be done by attatching aerodynamic structures to the horizontal links or extensions thereof or forming the horizontal links into aerodynamic shapes. It is worth noting that the areodynamic structures will be closer to the ground as the angle of bank increases, where ground effect is required this could be an advantage. However if not desired a suitable system/linkage could give any height above ground to bank angle relationship required.

5) According to another embodiment of the present invention or two, or more of the 3 or 4 wheeled units illustrated in FIG 1 may be joined together to form a multiple vehicle. Said units may be fitted with at least one specially shaped wheel (tyre) to allow the vehicle to be run on surfaces that control the vehicles direction(rails). This is illustrated in FIG 45 a). FIG 45 b) & c) show possible guide wheel forms whilst FIG 45 d) show a matching un guided wheel. Clearly wheel gyroscopic force cannot balance this type of vehicle and which must be leaned by applying torque between at least one horizontal link and the body or by applying torque between at least one horizontal link and at least one upright or the equivalent for a mono link. FIG 45 d) shows how to use a body mounted gyroscope to provide the torque. To accomodate variations in track width it must be possible to alter the effective length(s) of at least one of the horizontal links, or the track must be compliant or one wheel in each pair must run on a substantially flat track.

6) Compliance in bump/droop. It is usual to allow some degree of rearward movement of a wheel as it strikes a bump. There are many methods by which this could be done some are detailed below.
FIG 46 a) shows a subframe pivoted and sprung on the body.
FIG 46 b) shows a compressible wishbone, in this case in conjunction with a subframe but it could work with individually mounted horizontal links.
FIG 46 c) shows a wheel axle pivoted and rotationally sprung on an upright.
FIG 46 d) &e) show rotatable body to horizontal link mounts a variation of these would be ok for two part mono links.

7) Other means of achieving the required geometry.
FIG 47 a) shows a banking suspension where the body connects to only one horizontal link and an additional link is run from one upright (for preference from an existing upright to horizontal link connection) to the body, to control the angular disposition of the body and the upright. In this case the additional link is parallel to the horizontal links and the body and upright move through the same angle.
FIG 47 b) shows a banking suspension where the body connects to only one horizontal link and an additional link is run from one upright to the body, to control the angular disposition of the body and the upright. In this case the additional link is not parallel to the horizontal links and the body and upright move through different angles.
FIG 47 c) shows a banking suspension where the body is not connected to any horizontal link and two additional links are run from one upright to the body, to control the angular disposition of the body and the upright. In this case the additional links are parallel to the horizontal links and the body and upright move through the same angle. Clearly the links could be arranged to produce a none linear angular relationship between body and upright.
FIG 47 d) shows a banking suspension where the body is not connected to any horizontal link and two additional links are run one from each upright to the body forming a Watts linkage with the body as one of the members, which controls the angular disposition of the body and the uprights. In this case the additional links are parallel to the horizontal links and the body and uprights move through the same angle. Clearly the links could be arranged to produce a none linear angular relationship between body and upright. It would be possible to attatch the center point of the above watts linkage to one of the horizontal links or for it to be sprung on one of the horizontal links.
FIG 47 e) shows a banking suspension where the body is connected to one horizontal link and two additional links are run one from each upright to the body where in conjuction with a third additional link they form a Watts linkage attatched to the body to control the angular disposition of the body and the uprights. In this case the additional links are arranged to move the body and uprights move

through the same angle. Clearly the links could be arranged to produce a none linear angular relationship between body and upright.

All the 'other means' in 7) may be adapted to suit mono links.

BANKING SUSPENSION
KEY TO DIAGRAM NUMBERS.

1. Front wheel.
2. Rear wheel.
3. Wheel front or rear.
4. Vehicle body.
5. Upright.
6. Horizontal link.
7. Mono link.
8. Kingpin.
9. Extra member (refer to text for details).
10. Drag link .
11. Sliding pillar.
12. Leading/traling link.
13. Wishbone.
14. Subframe.
15. Leaf spring.
16. Damper.
17. Springing medium.
18. Universal joint.
19. Pivot.
20. Pivoted member.
21. Rotation locking device.
22. Sprocket or part thereof.
23. Belt, chain or similar.
24. Rack and pinion componentry.
25. Bevel gear.
26. Drive shaft.
27. Rail.

CLAIMS.

1a) A Banking Suspension comprises a pair of wheels are disposed laterally about the body of the vehicle and which are constrained by linkages such that, when the vehicle is upright and set to run straight ahead, the planes perpendicular to the axes of rotation of each of the paired wheels and passing through the tyre/road contact patch (hereafter 'planes of rotation of the wheels') are substantially parallel to the vertical plane through the center of the body. A means is provided of constraining the Banking Suspension in roll. If the roll constraint is removed (released) and the vehicle is leaned without forward speed or steering movement or the vehicle is equipped with a none steering Banking Suspension, then the planes of rotation of the of the wheels and the 'vertical' plane through the center of the body move in unison through substantially the same angle and thus remain substantially parallel. Where the Banking Suspension steers, then in normal use, the planes of rotation of the wheels will remain substantially parallel to each other within the limits imposed by the chosen steering geometry. They may not however remain parallel to the plane through the body. What will remain substantially parallel to the plane through the body are the lines joining the connections between the horizontal links and thier repective uprights. Whilst the perpendicular distance between the three planes will change as the roll angle increases, the lines of intersection of those planes with the (assumed flat) surface on which the vehicle stands will move only a little.

1b) A Banking Suspension may alternatively comprise a pair of uprights which carry the wheels and which are disposed laterally about the body of the vehicle and which are constrained by linkages such that, when the vehicle is upright and set to run straight ahead, vertical planes through the uprights are substantially parallel to the vertical plane through the center of the body. A means is provided of constraining the Banking Suspension in roll. If the roll constraint is removed and the vehicle is leaned without forward speed or steering movement or the vehicle is equipped with a none steering banking suspension, then the originally vertical planes through the uprights and the 'vertical' plane through the center of the body move in unison through substantially the same angle and thus remain substantially parallel. It is possible to give the wheels intial positive or negative camber relative to the originally vertical planes through the uprights which will mean that the planes of rotation of the wheels and the vertical plane through the body will not be parallel when the vehicle is upright or when rolled, however when the vehicle is rolled, the angles through which the planes of rotation of the wheels and the 'vertical' plane through the body rotate will be substantially the same and in the same direction. Whilst the distance between the three planes will change as the roll angle increases, the lines of intersection of those planes with the (assumed flat) surface on which the vehicle stands will move little.

1c) A Banking Suspension may alternatively comprise a pair of uprights which carry the wheels and are disposed laterally about the body of the vehicle and which are constrained by linkages such that, when the vehicle is upright and set to run straight ahead, vertical planes through the uprights are substantially parallel to the vertical plane through the center of the body. If the roll constraint is removed and the vehicle is leaned without forward speed or steering movement or the vehicle is equipped with a none steering banking suspension, then the originally vertical planes through the uprights and the 'vertical' plane through the center of the body move in the same direction but at different rates so that the three planes may become progressively less parallel as the angle of bank increases. It is possible to give the wheels intial positive or negative camber relative to the 'vertical' planes through the uprights which will make the planes of rotation of the wheels even less parallel than the vertical planes through the uprights. The distance between the three planes will change as the roll angle increases and the lines of intersection of the three planes with the (assumed flat) surface on which the vehicle stands will move a little or a lot depending on the geometry chosen.

Note in the claims that follow the term ' plane of rotation of the wheels' is also taken to cover the reference lines through the uprights as described in Claim 1b) and 1c).

2) A Banking Suspension as claimed in claim 1) wherein the means of achieving the control of the laterally disposed wheels shall comprise parallelogram or substantially parallelogram linkages.

CLAIMS RELATING TO ONE PIECE HORIZONTAL LINKS.

3) A Banking Suspension as claimed in claim 1) wherein control of the laterally disposed wheels is achieved, where the wheels are not to steer, by rotatably connecting two points on each of the wheel uprights that lie on or near the 'plane of rotation of the wheel ' by two horizontal, substantially parallel, equal (or near equal) length horizontal links(with pivots whose axes are for preference substantially longitudinal to the vehicle). The body is attached at or near the mid points of the horizontal links. If required, linkages and springing medium to absorb surface irregularities, are provided either, between the uprights and wheels and/or between the horizontal links and the body.

4) A Banking Suspension as claimed in claim 1) wherein control of the laterally disposed wheels is achieved, where the wheels are to steer, by rotatably connecting two points on each of the wheel uprights that lie on or near the 'plane of rotation of the wheel ' by two horizontal, substantially parallel, equal (or near equal) length horizontal links with pivots whose axes are for preference substantialy longitudinal to the vehicle. The upright to horizontal link's connections may be spherical joints so that the whole upright may swivel or the connections may be pivots whose axes are for preference substantially longitudinal to the vehicle,or one connection may be a pivot whose axis is for preference substantially longitudinal to the vehicle whilst the other connection is a spherical joint, kingpins mounted on the uprights carry the wheels and allow steering. The body is attached at or near the mid points of the horizontal links. If required, linkages and springing medium to absorb surface irregularities, are provided either, between the uprights and wheels and/or between the horizontal links and the body.

TWO PIECE HORIZONTAL LINKS.

5) A Banking Suspension as claimed in claim 1) wherein control of the laterally disposed wheels is achieved, where the wheels are to steer, by rotatably connecting two points on each of the wheel uprights that lie on or near the 'plane of rotation of the wheel ' to points on or near the center line of the body by means of two horizontal, substantially parallel, equal (or near equal) length horizontal links (four in all) with pivots whose axes are for preference substantially longitudinal to the vehicle. The horizontal links are in two substantially equal halves, each running from the body pivot to the wheel's upright, suspension movement to absorb surface irregularities is most readily provided by allowing relative rotation of the half horizontal links about the horizontal link to body connections and resisting that rotation without reference to the vehicle's body. The upright to horizontal link's connections may be spherical joints so that the whole upright may swivel. Or the connections may be pivots whose axes are for preference substantially longitudinal to the vehicle or one connection may be a pivot whose axis is for preference substantially longitudinal to the vehicle whilst the other connection is a spherical joint, where kingpins mounted on the uprights carry the wheels and allow steering.

6) A Banking Suspension as claimed in claim 1) wherein control of the laterally disposed wheels is achieved, where the wheels are not to steer, by rotatably connecting two points on each of the wheel uprights that lie on or near the 'plane of rotation of the wheel ' to the body by means of two horizontal, substantially parallel, equal (or near equal) length horizontal links with pivots whose axes are for preference substantialy longitudinal to the vehicle. The horizontal links are in two substantially equal halves, each running from the body pivot to the wheel's upright (four in all) , suspension movement to absorb surface irregularities is most readily provided by allowing relative rotation of the half horizontal links about the horizontal link to body connections and resisting that rotation without reference to the vehicle's body. The upright to horizontal link's connections may be spherical joints plus extra members so that the whole upright may not swivel or the connections may be pivots whose axes are for preference substantially longitudinal to the vehicle, or one connection may be a pivot whose axis is for preference substantially longitudinal to the vehicle whilst the other connection is a spherical joint, axles mounted on the uprights carry the wheels.

MONOLINKS.

7) A Banking Suspension as claimed in claim 1) wherein control of the relative angular relationship of the laterally disposed wheels and the body may be controlled by methods other than simple links. This form which is hereafter termed a 'mono link' uses a single upright to upright one piece horizontal link, where the angular dispositions of the 'planes of rotation of the wheels' and body's 'vertical' center plane, relative to the horizontal link(s) are controlled by other means, eg. cables, gears, hydraulic, pnuematic or electrical devices etc. Typically the mono link will connect to the body and uprights by pivots whose axes are for preference substantially longitudinal to the vehicle which are capable of absorbing all torques applied to the mono link. For the purposes of steering kingpins may be provided on the uprights, or other swiveling means may be provided.

8) A Banking Suspension as claimed in claim 1) wherein control of the relative angular relationship of the laterally disposed wheels and the body may be achieved methods other than simple links. This form of 'mono link' uses two body to upright half length horizontal links (one to each upright), where the angular dispositions of the 'planes of rotation of the wheels' and body's 'vertical' center plane, relative to the horizontal link(s) are controlled by other means, eg. cables, gears, hydraulic, pnuematic or electrical devices etc.Typically the mono link will connect to the body and uprights by pivots whose axes are for preference substantially longitudinal to the vehicle which are capable of absorbing all torques applied to the mono link. For the purposes of steering kingpins may be provided on the uprights, or other swiveling means may be provided.

CONTROL OF ANGLE OF ROLL

9) A Banking Suspension as claimed in claim 1) wherein control of the angle and/or rate of roll is controlled by the driver using the gyroscopic properties of the steered wheel(s).

10) A Banking Suspension as claimed in claim 1) wherein control of the angle and rate of roll is controlled by the use of powered systems that sense cornering related parameters and use them to control the angle of bank (including driver muscular effort exerted on appropriate linkages and his own sense of balance).

LIMITING THE ANGLE OF ROLL

11) A Banking Suspension as claimed in claim 1) wherein there is be some method of limiting the maximum roll angle of the vehicle, either within the suspension, the bank angle control system or more simply, by fitting small wheels or skids on sides of the body at the points of first contact with the surface travelled on.

NOTES ON THE CLAIMS TO THIS INVENTION.

As this patent outlines a new species of road vehicle, it is not suprising that there are miriads of possible practical, and not so practical embodiments. It is not possible to claim every permutation of geometry and physical form. Therefore the approach adopted is to break the invention down into functional elements and show the possible variations of those elements. Thus the claims are stated to cover all permutions of the variations of the elements claimed.

CLAIMS TO THE GENERAL LAYOUT OF VEHICLES PRODUCED ACCORDING TO THE INVENTION.

12) Claim is made to the usage of a Banking Suspension in a vehicle configured as follows. A three wheeled vehicle which has a single front wheel and a pair of rear wheels which are those of a banking suspension.

13) Claim is made to the usage of a Banking Suspension in a vehicle configured as follows. A three wheeled vehicle which has a pair of front wheels which are those of a banking suspension and a single rear wheel

14) Claim is made to the usage of a Banking Suspension in a vehicle configured as follows. A four wheeled vehicle which has a pair of front wheels which are those of a banking suspension and a pair of rear wheels which are those of another banking suspension.

15) Claim is made to the usage of a Banking Suspension in a vehicle where the paired wheels are disposed about the body with lateral and longitudinal symetry.

16) Claim is made to the usage of a Banking Suspension in a vehicle where the paired wheels are disposed about the body with lateral and /or longitudinal asymetry. This may be minor, due to the physical/geometerical embodiment chosen or gross and deliberate.

CLAIMS ON THE GEOMETRIES OF BANKING SUSPENSIONS

CLAIMS FOR GEOMETRIES OF HORIZONTAL LINK TO WHEEL UPRIGHT CONNECTIONS

17) A Banking Suspension as claimed in claim 1) and claims 3) 4) 5) & 6) wherein the connections between the horizontal links and the uprights occour on or near the plane of rotation of the wheels in any of the following relationships to the wheel or it's axis .
a) Both pivots above the wheel.
b) One pivot above the wheel, one pivot on or near the wheel's axis of rotation.
c) One pivot above the wheel, one pivot above the wheel's axis of rotation.
d) One pivot above the wheel, one pivot below the wheel's axis of rotation.
e) Both pivots within the wheel, both above pivots above the wheel's axis of rotation.
f) Both pivots within the wheel, both above pivots below the wheel's axis of rotation.
g) Both pivots within the wheel, one pivot above, one pivot below, the wheel's axis of rotation.
h) Both pivots within the wheel, one pivot above, one pivot on, the wheel's axis of rotation.
i) Both pivots within the wheel, one pivot below, one pivot on, the wheel's axis of rotation.
Each connection may be inboard or outboard of the plane of rotation of the wheels.
Connections may or may not be vertically aligned.

18) A Banking Suspension as claimed in claim 1) and claim 17) wherein the connections between the uprights and the horizontal links are ;
a) axial pivots whose axes are substantially longitudinal to the vehicles body.
b) axial pivots whose axes are not longitudinal to the vehicles body.
c) spherical joints.
d) an axial pivot of arbitry inclination and a spherical joint.

19) A Banking Suspension as claimed in claim 18 a) b) and d) wherein the uprights carry a kingpin, or other means of swiveling the wheel's axle, for the purposes of steering the wheels. The kingpin's axis of rotation may be aligned with the horizontal link to upright connections of it's upright or may follow any arbitry line.

20) A Banking Suspension as claimed in claims 1 3,4,5 & 6 wherein mono links are utilised, the connections between the structural member of the mono link and the uprights occour on or near the plane of rotation of the wheels in any of the following relationships to the wheel or it's axis .
a) Mono link connects to upright above the wheel .
b) Mono link connects to upright within wheel, above the axis of rotation of the wheel.
c) Mono link connects to upright within wheel, below the axis of rotation of the wheel.
d) Mono link connects to upright within wheel, on the axis of rotation of the wheel.
The structural member's connection to the upright may be inboard or outboard of the plane of rotation of the wheels.
The connection of the control element of the mono link to the upright may be at any arbitry position on the upright.

CLAIMS FOR GEOMETRIES OF HORIZONTAL LINK TO BODY CONNECTIONS

21) A Banking Suspension as claimed in claim 1) wherein the connections between the horizontal links and the body are
a) Simple connections (usually both axial pivots, although one axial and one spherical joint is possible), one per horizontal link and only two in total, for use where the horizontal links are in one piece and run from upright to upright.
b) Co-linear connections for use with two part horizontal links. Where axial pivots/spherical joints are used which share the same axis. Usually all four joints are axial pivots, although one axial pivot and one spherical joint per side is possible. There will be one body connection per half horizontal link and four in total.
c) Laterally disposed connections where the horizontal links do not cross, for use where the horizontal links are in two parts and run from body to upright they may be symeterically disposed about the center line, although the disposition does not have to be symeterical horizontally or vertically about the center line, spacing of top and bottom links does not have to be the same, and all links may connect entirely on one side of the body's center line. Connection types to be as in b).
d) Laterally disposed connections where the links cross for use where the horizontal links are in two parts and run from body to upright, they may be symeterically disposed about the body center line, although the disposition does not have to be symeterical about the center line, spaceing of top and bottom links does not have to be the same, and all links may connect entirely on one side of the body's center line. Clearly the links must be arranged so they do not foul each other when in operation.Connection types to be as in b).
e) Vertically disposed connections for use where the horizontal links are in two parts and run from body to upright. They may be disposed on the center line, although the disposition does not have to be vertically or laterally symeterical, or on the center line. The links to one upright may connect above and below the links to the other upright or may connect on the 'wrong' side of the center line,ie cross or may connect at essentially random positions.Connection types to be as in b).

N.B.The claim implise that top and bottom horizontal links will be of the same type, however, any of the top body to horizontal link connections may be used in conjunction with any of the bottom body to horizontal link connections.

CLAIMS FOR GEOMETRIES OF MONO LINK TO BODY CONNECTIONS

22) A Banking Suspension as claimed in claim 1 7 & 8 wherein the connections between the mono link and the body are

a) Single connection to the body, usually an axial pivot, for use where the mono link runs from upright to upright.
b) Co-linear (or possibly co-axial) connections, usually axial pivots, for use with two part mono links where the half mono links runs from body to upright, the body to half mono link connections do not have to be on body's center line.
c) Laterally disposed connections for use with two part mono links where the two half mono links run from body to upright, where the mono links do not cross, they may be symeterically disposed about the body center line, although the disposition does not have to be symeterical horizontally or vertically about the center line, and both mono links may connect entirely on one side of the center line.
d) Laterally disposed connections for use where the mono link is in two parts running from body to upright where the links cross, they may be symeterically disposed about the body center line, although the disposition does not have to be symeterical about the center line and may be entirely on one side of the center line. Clearly the mono links must be arranged so they do not foul each other when in operation.
e) Vertically disposed connections for use where the mono link is in two parts running from body to upright, they may be disposed on the center line, although the disposition does not have to be vertically symeterical, or on the center line.

23) A Banking Suspension as claimed in claim 1, 21 & 22 wherein the orientation of the axes of the body to horizontal link connections in the for preference vertical longitudinal plane through their point of contact with the body is horizontal, points down to the front or points up to the front, or is parallel or none parallel. The axes do not have to lie within the vertical longitudinal plane or be parallel to it.

CLAIMS ON SPRINGING MEDIA .

N.B. For the purposes of these claims, the term springing medium is taken to mean any system or component that may be connected between two points or surface areas and will resist and/or control/damp relative movement, including relative rotation, between those two points. eg coil spring and damper, rubber block, hydraulic, pnuematic and magnetic systems etc. It is also envisiged that the front and rear systems may be interlinked by a means that transfers force between the two (or more) irregularity absorbing linkages of the vehicle) eg an hydraulic interlink, or an interlink may be achieved by a system that uses information and power systems to give the same effect eg active suspension.
Also, for the purposes of these claims, the term irregularity absorbing linkage is used to describe that part of the suspension whose purpose is to protect the vehicle and it's occupants from shock loads imposed by running the vehicle on an irregular surface. It may comprise a set of components for this specific purpose or it may exist as a side effect of the physical embodiment of the banking suspension chosen.

24) A Banking Suspension as claimed in claim 1 wherein there is used a springing medium is in one of the four catagories below, N.B. This claim applys equally well to mono links.

1) Where the medium acts between the body or an extension thereof and :
a) One or both of the upright to upright horizontal links or an extension thereof.
b) One or both per side of the upright to body horizontal links or an extension thereof.
c) A part of a surface irregularity absorbing linkage which intervenes between the body and the horizontal links or an extension thereof.
d) An 'extra' member or system of members which acts between anyr of the parts above and the springing medium.

2) Where the medium acts between the wheel's axle or an extension thereof or part of an upright mounted irregularity absorbing linkage and the upright or an extension thereof

3) Where the springing medium acts between a body to horizontal link connection pivot or an extension thereof and a horizontal link or an extension thereof, or the springing medium acts between at least two of the horizontal links without reference to the body, in these cases, the springing medium rotates about the body in unison with the horizontal links(split or other wise).

4) Where the springing medium(media) act between at least two horizontal links and at least one extra member which pivots on the body but does not exert a torque on the body in normal use.

CLAIMS ON ROTATIONAL RESTRAINTS AS APPLIED TO THE CURRENT INVENTION.

N.B. This claim (25) applys equally well to mono links.

25) A Banking Suspension as claimed in claim 1 wherein there is used a rotational restraint. This may take the form of a temporary irrotatable connection between the body or an extension thereof or a part of an irregularity absorbing linkage that is irrotatable relative to the body about the (for preference) longitudinal axis of the vehicle AND
a) At least one of the horizontal links or a part of the irregularity absorbing linkage that is irrotatable relative to at least one of the horizontal links about the (for preference) longitudinal axis of the vehicle

b) The extra member where the springing medium(media) act between the at least two horizontal links and at least one extra member which is rotatably connected to the body but does not exert a significant torque on the body in normal use. i.e. section 4 of claim 24.

The temporary irrotatable connection may be rigid or be displaceable under torque such that the vehicle will exhibit 'normal' (car like) roll when cornered. This claim is taken to cover all known practice of rotational brakes. It may be be under driver control, although automatic activation, possibly in conjuction with automatic centering (or rendering of the vehicle vertical) of the banking suspension is also claimed.

CLAIMS FOR BANKING SUSPENSIONS THAT UTILISE CONTINUOUS UPRIGHT TO UPRIGHT HORIZONTAL LINKS WHERE THE HORIZONTAL LINKS ARE STRAIGHT.

26) A Banking Suspension as claimed in claim 1 wherein there are used straight horizontal links. In the context of the present claims the word 'straight' when refered to horizontal links is taken to mean that a line joining the two upright to horizontal link connections and the body to horizontal link (or intervening irregularity absorbing linkage to horizontal link) connection, when viewed from above is substantially straight. Claimed are forms where line is substantially perpendicular to the body's longitudinal axis, as also where it is not. Within the context of this claim the axes of the connection pivots may be perpendicular to this (the straight) line and parallel to each other, but they do not have to be. The links themselves may be of any arbitry shape when viewed from above. The line between the connection points when viewed from the front/back does not have to be straight.

27) A Banking Suspension as claimed in claim 1 wherein there are used two straight one upright to upright horizontal links, each of which connects to the uprights and is rotatably connected directly to the body. In this case surface irregularity absorbing linkages, if provided, will be between the uprights and the wheel axles and could follow standard automotive practice. Typical examples would be sliding pillar or leading/trailling link(s). Also claimed, where the top and bottom horizontal links are of unequal length, is the provision of the possibility of at least one body to horizontal link pivot being able to move, or the possibilty of allowing at least one horizontal link to upright pivot to move, or the making of at least one horizontal link flexible in the correct plane. This may be needed to accomodate changes in connection point separation.

28) A Banking Suspension as claimed in claim 1 wherein there two straight continuous horizontal links that rotatably connect to the uprights and are individually rotatably connected to an irregularity absorbing linkage that comprises a pair of wishbones. The wishbones are (for preference) arranged to pivot about the body on an axis substantially perpendicular to the vertical plane through the center of the body. The wishbones may be of equal or unequal length, parallel or non- parallel as required. The connections of the wishbones to the horizontal links may take several different forms.

a) The connection comprises a pivot whose axis is (for preference) substantially longitudinal to and substantially in the plane of, the wishbone. This has the effect of rotating the horizontal links as the wishbones move up and down. The method is therefore only suited to a horizontal link where the upright to horizontal link connection is via a spherical joint or other means is provided to absorb the twist induced.

b) The connection comprises a pivot whose axis is(for preference) substantially longitudinal to and substantially in the plane of, the wishbone, where another pivot is provided whose axis is (for preference) substantially parallel to that of the body to wishbone pivot and the horizontal link. This later pivot connects to the first pivot and rotatably connects to the horizontal link. The horizontal link is not allowed to move axially with respect to the second pivot. This arrangement does not have to rotate the horizontal links as the wishbones move up and down. The method is therefore suited to any form of horizontal link to upright connection.

c) The connection comprises two pivots of the function described in b). But applied in reverse order. A pivot whose axis is (for preference) substantially parallel to the axis of the body to wishbone connection is attatched at the wishbone's tip. A second pivot connects to the first such that it's axis is (for preference) perpendicular to the first and substantially horizontal. This later pivot connects the horizontal link and the first pivot. The first pivot is not allowed to move axially with respect to the wishbone. This has the effect of absorbing the rotation of the horizontal links as the wishbones move up and down. The method is therefore suited to any form of horizontal link to upright connection.

d) The horizontal link's central connections are made to a subframe. The body to subframe irregularity absorbing linkage comprises a pair of wishbone on the tip of each is a pivot whose axis is (for preference) substantially parallel to the axis of rotation of the wishbone relative to the body. The subframe is attatched to these pivots.

e) The connection comprises a single wishbone and one extra member. A pivot whose axis is (for preference) substantially perpendicular to the axis of rotation of the wishbone is attatched at the wishbone's tip. A subframe is attatched to the pivot. The subframe carries the horizontal links. A subsiduary link is provided between the body and the subframe to control the angular relationship of the body and the subframe.

f) The irregularity absorbing linkage comprises a single wishbone which is arranged to pivot about about (for preference) an axis substantially perpendicular to the vertical plane through the center of the body. A subframe is rigidly attatched to the wishbone at or near it's tip. The subframe carries the horizontal links, alternatively this may be viewed as a subframe extended rearwards/forewards and pivoted on the body.

The wishbones may be all leading, all trailing or acting as a watts linkage. Any of the horizontal link connections described in a), b), c) above may be used in conjunction with any other. If the pivots between a single horizontal link and it's wishbone in a),b),c) or between the horizontal link and the subframe claim d),e),f) are sufficiently strong and that horizontal link's connections with the uprights are axial pivots, again of sufficient strength, then any or all of the other horizontal links connections may be spherical joints.

29) A Banking Suspension with irregularity absorbing linkages as claimed in claim 27 wherein the wishbones may be of arbitry shape when viewed in plan. It is possible to make the wishbones substantially 'U' shaped in plan such that the space within the wishbones may be occupied by other items, eg the riders feet..

30) A Banking Suspension with irregularity absorbing linkages as claimed in claim 1 wherein there are two straight continuous horizontal links that rotatably connect to a surface irregularity absorbing linkage that itself connects to the body, plus uprights and associated components, where the irregularity absorbing linkage comprises at least one slider. The slider may carry a subframe which itself carries both of the central horizontal link connections or may comprise two sliders each of which connects to a horizontal link. Clearly, at least one slider must not rotate perpendicular to it's line of movement. It is also clear that where there are two sliders and thier movement is not linear and parallel then they are analogous to the tips of wishbones and the variations of pivot arrangements required to absorb relative rotation of the horizontal links described for the tips of wishbones (claim 28) may be applied here. The slider(s) do(es) not have to move in a straight line when viewed from the side or front or top nor do they have to stay, or ever be, in the 'vertical' central plane of the body. Also claimed is the use of a slide and a wishbone within the same surface irregularity absorbing linkage.

31) A Banking Suspension with irregularity absorbing linkages as claimed in claim 1 wherein there are two straight continuous horizontal links that rotatably connect to the body and to the uprights plus associated components, where both of the horizontal links comprise single or multi leaf leaf springs. Clearly there will be additional components required to provide damping of the banking suspension.

32) A Banking Suspension with irregularity absorbing linkages as claimed in claim 1 wherein there are two straight continuous horizontal links, one of which rotatably connects to the body or an extension thereof and comprises single or multi leaf leaf spring, whilst the other is inflexible and connects to the body via an irregularity absorbing linkage that allows the center of the second horizontal link to move vertically relative to the body, plus uprights and associated components.

33) A Banking Suspension with irregularity absorbing linkages as claimed in claim 1 which comprises a straight continuous horizontal link which rotatably connects to the body or an extension thereof and itself comprises a single or multi leaf leaf spring and a pair of half length horizontal links which rotateably connect to the body such that damping the relative rotation of the half links will damp the movement of the whole banking suspension.

CLAIMS RELATING TO THE MOUNTING OF THE SPRINGING MEDIUM.

34) A Banking Suspension with irregularity absorbing linkages as claimed in claim 1 and claims 26 to 33 where the irregularity absorbing linkage is of the form of slider(s) or wishbone(s) and the springing medium acts between the body or an extension thereof and a member of the irregularity absorbing linkage.

35) A Banking Suspension with irregularity absorbing linkages as claimed in claim 1 and claims 26 to 33 where the horizontal links are mounted individually on wishbones. The mounting of the springing medium is as follows. A pivot is provided whose axis is (for preference) substantially parallel to the longitudinal axis of the body and crosses or passes close to the axis of the wishbone to body connection, at or near the crossing point the longitudinal pivot is universally connected to an extension of the horizontal link, said extension passing through a bearing at or near the tip (or in/on the body) of the wishbone. Due to the action of the universal coupling the longitudinal pivot and the horizontal link rotate in unison. The springing medium acts between an extension of the body mounted longitudinal pivot or the body mounted longitudinal pivot itself and the horizontal link or an extension thereof.

36) A Banking Suspension with irregularity absorbing linkages as claimed in claim 1 and claims 26 to 33 where the horizontal links are mounted on a subframe which is in turn mounted on wishbones.This comprises a pivot whose axis is (for preference) substantially parallel to the longitudinal axis of the body and whose axis crosses or passes close to the axis of the wishbone to body connection. At or near the crossing/near point the longitudinal pivot is universally connected to an extra member which passes through a bearing within the wishbone, at or near the tip of the wishbone for preference at or near where the axis of the extra member intersects the axis of the pivot whose axis is parallel to the body to wishbone pivot said extra member is universally connected to an extension of the horizontal link which passes through the subframe and may also provide the horizontal links pivot within the subframe. Due to the action of the universal couplings and the extra member the longitudinal pivot and the horizontal link rotate in unison. The springing medium acts between an extension of the body mounted longitudinal pivot or the pivot itself and the extra member or the horizontal link or an extension thereof .

CLAIMS FOR BANKING SUSPENSIONS THAT UTILISE CONTINUOUS UPRIGHT TO UPRIGHT HORIZONTAL LINKS WHERE THE HORIZONTAL LINKS ARE CRANKED AND DO NOT ROTATE ABOUT THE AXES OF THIER CENTRAL PORTIONS.

In the context of these claims the term 'cranked horizontal links', is taken to mean horizontal links where, when viewed from above, the upright and body connection points on the link are not in a straight line. For preference the horizontal links are substantially 'U' shaped, 'Z' shaped horizontal links or horizontal links of arbitrary shape, are not, however, precluded. When viewed from the front/rear the connection points may or may not lie on a straight line.

37) A Banking Suspension with irregularity absorbing linkages as claimed in claim 1 where a banking suspension may comprise a pair of cranked, continuous upright to upright links plus the uprights, wheels and other associated componentry there are several variations

a) Cranked horizontal links which connect directly to the body and where the irregularity absorbing linkage, if any is provided on the uprights.

b) Cranked horizontal links which are mounted on a subframe and that subframe may be mounted on wishbones, slides or be an extended, pivoted subframe.

CLAIMS FOR BANKING SUSPENSIONS THAT UTILISE CONTINUOUS UPRIGHT TO UPRIGHT HORIZONTAL LINKS WHERE THE HORIZONTAL LINKS ARE CRANKED AND ROTATE ABOUT THE AXES OF THIER CENTRAL PORTIONS.

38) A Banking Suspension with irregularity absorbing linkages as claimed in claim 1 where there are a pair of cranked, continuous upright to upright horizontal links that may rotate about the axes of their central portions, plus the uprights, wheels and other associated componentry.

a) Cranked horizontal links which connect directly to the body and where irregularity absorbing movement is provided by allowing the horizontal links to rotate about the axis of that portion that connects to the body. In this case the first of the two required pivots is longitudinal to the body and the second is coaxial with the axis of the central portion of the horizontal links.
b) Cranked horizontal links which connect directly to the body and where irregularity absorbing movement is provided by allowing the horizontal links to rotate about the axis of that portion that connects to the body. In this case the first of the two required pivots is longitudinal to the body and the second is parallel to and coaxial with or offset from the axis of the central portion of the horizontal links.
d) Cranked horizontal links which connect directly to the body and where irregualrity absorbing movement is provided by allowing the horizontal links to rotate about the axis of that portion that connects to the body. In this case the first of the two required pivots is parallel to the axis of the inner portion of the horizontal links and the second is longitudinal to the body.

39) A Banking Suspension with irregularity absorbing linkages as claimed in claim 1 where the cranked horizontal links rotate about thier central portion, are mounted on a subframe and that subframe is mounted on wishbones. Where the wishbones and the horizontal links are interlinked so that suspension movement is shared predictably between them or such that the horizontal links retain a substantially constant orientation to the ground. The subframe may alternatively be mounted on a slider or on an extended, pivoted subframe or be the center of a watts linkage.

CLAIMS RELATING TO MOUNTING THE SPRINGING MEDIUM.

40) A Banking Suspension with irregularity absorbing linkages as claimed in claim 1 and claims 38 & 39 where the springing medium is mounted ;
a) Between the body or an extension thereof and an extension of the horizontal link. This will work well when the vehicle is upright but as the vehicle leans the line of action of the springing medium becomes progressively less ideal.
b) Between the body or an extension thereof and an extra member pivoted on the horizontal link such that when viewed from the front/rear, it is free to rotate on the horizontal link but is retained at substantially the original orientation (ie in the 'vertical' or an arbitry plane of the vehicle) to the body such that the point of connection with the springing medium does not move in the plane perpendicular to the longitudinal axis of the vehicle. This will work well when the vehicle is upright and as the vehicle leans the line of action of the springing medium remains acceptable.
c) Between an extension of a horizontal link and the for preference longitudinal body to horizontal link pivot of that link or an extension thereof or to a (possibly) connected, pivot substantally coaxial with the first longitudinal pivot, such that both mounts of the springing medium rotate in unison with the horizontal link.
d) Between the horizontal link and the pivot about which it rotates, both rotating in unison.
e) Where the horizontal link is mounted on a wishbone the springing medium may be used to oppose the rotation of the horizontal link relative to the wishbone.
In each of the above cases the rotational restraint may act on the body/central pivot of either horizontal link.

CLAIMS RELATING TO BANKING SUSPENSIONS THAT UTILISE TWO PART HORIZONTAL LINKS THAT RUN FROM THE BODY CONNECTION TO THE UPRIGHT CONNECTION. WHERE THE HORIZONTAL LINKS ARE STRAIGHT.

The term straight with respect to two part horizontal links for preference means that a line drawn perpendicular to the half horizontal link to body connection's axis and through that connections center will pass through or near the center of the half horizontal link to upright connection.
However a looser definition applies in many cases i.e. that the horizontal link is literally substanially straight between it's body and upright connections along a line that does not have to be perpendicular to it's body pivot axis.

41) A Banking Suspension with irregularity absorbing linkages as claimed in claim 1 where there are two pairs of stralght upright to body horizontal links, each of which may rotate about the (for preference) longitudinal axis of it's body pivot, plus the uprights, wheels and other associated componentry. There are several variations of the horizontal link to body pivot layout.

a) Assymeterical track, links perpendicular to body.
b) Symeterical track, links not perpendicular to body.
c) Uprights fore/aft of body connection, symeterical track.
d) Uprights fore/aft of body connection, assymeterical track

CLAIMS RELATING TO MOUNTING THE SPRINGING MEDIUM.

42) A Banking Suspension with irregularity absorbing linkages as claimed in claim 1 & claim 41 where ;
1) the springing medium acts directly between at least two of the half links or extensions thereof.
a) Springing medium acting between extensions of the half links.
b) Springing medium acting in shear between the half links.
c) Springing medium rotatably connected to the body and has extensions to form the half links.
d) Springing medium in shear between central extensions of the half links.

2) where the springing medium acts between two of the half links or extensions thereof via an extra member pivoted on the body and possibly other links.
a) A pair of springing media, each one acting between an end of an extra pivoted member and one of the half links.
b) Springing medium acting between the half links and a bell crank pivoted coaxial with or close to the half link pivots.
c) As b) with the Springing media attached to the same point on what is now a link.
d) The Springing medium takes the form of a leaf spring pivoted to the body and connected via links to the the horizontal half links.
e) A springing medium is pivoted coaxial with or close to the horizontal half link pivots and is connected to the horizontal half links via other links.

CLAIMS RELATING TO BANKING SUSPENSIONS THAT UTILISE TWO PART HORIZONTAL LINKS THAT RUN FROM THE BODY CONNECTION TO THE UPRIGHT CONNECTION. WHERE THE HORIZONTAL LINKS ARE CRANKED AND DO NOT ROTATE ABOUT THE AXES OF THIER INNER PORTIONS.

The term cranked two part (split) horizontal links, is taken to mean links where, when viewed from above, the upright and body connection points are not in the plane perpendicular to the axis of and through the center of the body to half horizontal link's connection. For preference the links are substantially 'L' shaped, although the angle formed by the arms of the 'L' will typically be greater than 90 degrees. Links of arbitry shape are not precluded.

43) A Banking Suspension with irregularity absorbing linkages as claimed in claim 1 where there are two pairs of cranked, upright to body horizontal links which do not rotate about the axes of thier inner portions, plus the uprights, wheels and other associated components. The claims relating to the possible arrangements of horizontal links and use of springing media are substantially the same as for straight two piece horizontal links.

CLAIMS RELATING TO BANKING SUSPENSIONS THAT UTILISE TWO PART HORIZONTAL LINKS THAT RUN FROM THE BODY CONNECTION TO THE UPRIGHT CONNECTION. WHERE THE HORIZONTAL LINKS ARE CRANKED AND ROTATE ABOUT THE AXES OF THIER INNER PORTIONS IN ORDER TO PROVIDE IRREGULARITY ABSORBING MOVEMENT.

44) A Banking Suspension as claimed in claim 1 where there are two pairs of cranked, upright to body horizontal linkswhich rotate about the axes of thier inner portions thus providing part or all of the irregularity absorbing means plus the uprights, wheels and other associated components.

45) A Banking Suspension with irregularity absorbing linkages as claimed in claim 1 where there are two part cranked horizontal links which connect to the body and where irregularity absorbing movement is provided by allowing the cranked two part horizontal links to rotate about the axis of that portion that connects to the body. There are several forms of articulation as follows;
a) The axis of the first of the two required pivots is (for preference) longitudinal to the body and the second (n.b. there are two of them) is (for preference) parallel to the axis of the inner portion of the horizontal links.

b) The axis of the first of the two (of which there are two) required pivots is (for preferrence) parallel to the axis of the inner portion of the link and the axis of the second pivot is (for preference) longitudinal to the body.
c) The axis of the first of the two (of which there are two) required pivots is (for preference) longitudinal to the body and the axis of the second pivot is (for preference) parallel to or coxial with the axis of the inner portion of the link.
d) The axis of the first of the two (of which there are two and they are separate) required pivots is not longitudinal to the body and the axis of the second pivot is not parallel to or coxial with the axis of the inner portion of the link. This is the none orthogonal equivalent of a). The none orthogonal equivalents of b) & c) are self evident.

CLAIMS RELATING TO MOUNTING THE SPRINGING MEDIUM.

46) A Banking Suspension with irregularity absorbing linkages as claimed in claim 1 and claims 43 to 45 utilising springing media mounted in the following ways ;

1) Where the springing medium acts between a body to horizontal link connection pivot or extension thereof and a horizontal link or extension thereof on each side of the body.
a) Using springing media in compression/tension.
b) Using springing media in torsion.

2) Where the springing medium acts between two horizontal links or extension thereof and a member pivoted on the body, or the springing medium is the pivoted member.

3) Where the springing medium acts between a pair of horizontal links of opposed crank or extensions thereof, one on each side of the body.
a) Using media in torsion .
b) Using media in compression/tension.
c) Using a member pivoted on the body.

CLAIMS RELATING TO BANKING SUSPENSIONS THAT UTILISE ONE ONE PIECE HORIZONTAL LINK (MONO LINK) THAT RUNS FROM UPRIGHT CONNECTION TO UPRIGHT CONNECTION.

47) A Banking Suspension with irregularity absorbing linkages as claimed in claim 1 which utilises Mono link banking suspensions wherein the main loads and torques are absorbed by one major link whilst other means are provided to control the relative angular positions of the 'vertical' central plane of the body, and the 'plane of rotation of the wheels'. Ideally the 'other means' will fit within the 'major' link although they do not have to. It is possible to arrange the 'other means' such that the body and uprights do not roll through the same angle and/or such that the angular relation between the body and uprights is not linear. The surface irregularity absorbing linkage, if provided, may be between the mono link and the body, or between the uprights and the wheels, in each case the forms described for upright to upright horizontal links apply,. There are many means by which the angular relationship of the uprights and body may be controlled.
a) A parallel single upright to upright horizontal control link or two half horizontal body to upright control links which are very close to, or within, the mono link. The control link(s) may be spherically connected.
b) Hydraulic/electrical/pnuematic control via suitable actuators and control systems.
c) Cable or other inextensible medium control.
d) Use of bevel gears or sectors thereof. In this case bevel gears or sectors thereof are irrotatably attatched to the body and uprights (for preference with their axes longitudinal to and coaxial with the body/upright to mono link pivot). Each of the abovebevel gears has a matching bevel gear or sector thereof which is irrotatably attatched to a shaft that runs from upright to upright. This shaft (or there may be two shafts, each of which runs from body to upright and has two bevel gears mounted irrotatably upon it) will rotate freely in bearings in/on the monolink or in bearings mounted in mounts that pivot substantially coaxially with thier matching bevel gear's axis.

e) Use of chains or toothed belts. Sprockets or sectors thereof are irrotatably attatched to the body and uprights (for preference with their axes longitudinal to and coaxial with the body/upright to mono link pivot). Then either, a belt/chain runs from upright to upright with at least one central point attatched to the body, or there are two body mounted sprockets and two belts/chains each of which run from body to upright.

f) Use of rack and pinion gears or sectors thereof. Gears or sectors thereof are irrotatably attatched to the body and uprights. Each of the above has a matching rack or section thereof which is attatched to or forms a rod that runs from upright to upright. The rod runs freely in bearings in the monolink or in bearings mounted in mounts that pivot coaxially with the matching pinion gear's axis The body or upright rack and pinion may be replaced by a simple, for preference, longitudinal pivot or spherical joint. The control link may be in one piece from upright to upright or in two pieces from body to upright.

CLAIMS RELATING TO BANKING SUSPENSIONS THAT UTILISE TWO PIECE MONO LINKS EACH OF WHICH RUN FROM UPRIGHT CONNECTION TO BODY CONNECTION.

48) A Banking Suspension with irregularity absorbing linkages as claimed in claim 1 which may comprise two half length mono links each of which runs from body to upright, plus the uprights, wheels and other associated components. The surface irregularity absorbing movement will be provided by allowing the relative roatation of the two mono links about the body and controlling this using the methods outlined for two piece straight links.

There are many methods by which the angular relationship of the uprights and body may be controlled.

a) Two half horizontal body to upright control links which are very close to or within the split mono links. The control links may be spherically connected.

b) Hydraulic/electrical/pnuematic control via suitable actuators and control systems.

c) Cable or other flexable inextensible medium control.

d) Use of bevel gears or sectors thereof. In this case bevel gears or sectors thereof are irrotatably attatched to the body and uprights (for preference with thier axes longitudinal to and coaxial with the body/upright to horizontal link pivot). Each of the above has a matching bevel gear or sector thereof which is irrotatably attatched to a shaft that runs from upright to body, these shafts will rotate freely in bearings in the mono link or in bearings mounted in mounts that pivot substantially coaxially with the matching bevel gear's axes.

e) Use of chains or toothed belts. Sprockets or sectors thereof are irrotatably attatched to the body and uprights (for preference with their axes longitudinal to and coaxial with the body/upright to mono link pivot). There are two belts/chains each of which runs from body to upright. The belt/chain requires a sprocket at one end only, the other may simply be fastened to the body/upright.

f) Use of rack and pinion gears or sectors thereof. Gears or sectors thereof are irrotatably attatched to the body and uprights. Each of the above has a matching rack or section thereof which is attatched to or forms a rod that runs from body to upright. The rod runs freely in bearings in the mono link or in bearings mounted in mounts that pivot coaxially with the matching pinion gear's axis The body or upright rack and pinion may be replaced by a simple for preference longitudinal pivot, the control link will be in two pieces each running from body to upright.

N.B. Clearly mono links, be they single or two part, may be cranked if required and may be arranged to rotate about thier central portions, the control can then be adapted to suit.

CLAIMS RELATING TO THE POWERING OF THE WHEELS OF A BANKING SUSPENSION.

49) A Banking Suspension as claimed in claim 1 in which at least one, but for preference both wheel(s) of a banking suspension may be driven by motors and appropriate transmission means mounted on the upright(s). These motors may be prime movers in thier own right or may be driven from a power source mounted elsewhere, usually the body, in the vehicle. Examples of the first would be i.c. engines on the uprights and examples of the last would be electric motors driven by batteries or hydraulic motors driven by an i.c. engine driven pump.

CLAIMS RELATING TO BELT DRIVE

50) A Banking Suspension as claimed in claim 1 in which power is transmitted to at least one wheel of a banking suspension from a body mounted power source by a chain or toothed belt sprocket or flat or v belt pulley or other driving means rotatably mounted on the body and driven from the power source by appropriate transmission means, a chain or toothed belt sprocket or flat or v belt pulley or other driven means mounted rotatably on the upright in conjunction with a means of changing the rotation of said driven means through the angle required to drive the wheel (typically a pair of bevel gears) and the connection to the wheel, a chain, toothed, flat or v belt or other transmission means which connects the driving and driven means and methods to ensure the correct tension and location of the transmission means. There are several variations;

a) The driving means will be mounted on the body coaxially with the body to horizontal link connection for one horizontal link or coaxially with the body to mono tube link connection, the driven means will be mounted on the upright coaxially with the upright to horizontal link connection for the same horizontal link or coaxially with the the upright to mono tube link connection, this arrangement gives zero change in transmisssion means length when the vehicle banks.

b) The driving means will be rotatably mounted on the body along the line joining the two body to horizontal link connections or an extension thereof or 'vertically' above/below the mono tube to body connection, the driven means will be rotatably mounted on the upright along the line joining the upright to horizontal link connections or an extension thereof in the same relative position as the driving means has to the body to horizontal link connections or the driven means will be mounted as far above/below the mono tube to upright connection the driving means was on the body. Also the axes of rotation of the driving and driven means will be longitudinal to the body and parallel to each other. This arrangement gives zero change in transmisssion means length when the vehicle banks.

c) The driving means will be rotatably mounted on the body with a known offset from the line joining the two body to horizontal link connections or an extension thereof or at a known positiion relative to the mono tube to body connection, the driven means will be rotatably mounted on the upright with the same offset from the line joining the upright to horizontal link connections or an extension thereof in the same relative position as the driving means has to the body to horizontal link connections or the driven means will be mounted at the same relative position to the mono tube to upright connection as the driving means has to the body to horizontal link connection. Also the axes of rotation of the driving and driven means will be parallel but may not be longitudinal to the body. This arrangement gives zero change in transmisssion means length when the vehicle banks.

51) A Banking Suspension as claimed in claim 1 in which power is transmitted to both wheels of a banking suspension from a body mounted power source. Each wheel requires a transmission method as outlined in claim 49. There will be required the provision of two body mounted driven means which may be irrotatably locked together, mounted coaxially or not, driven seperatly, rotate independantly in the same or opposite sense, or be connected by a differential.

CLAIMS RELATING TO GEAR DRIVE.

52) A Banking Suspension as claimed in claim 1 in which power is transmitted to drive at least one wheel of a banking suspension from a body mounted power source. The transmission may comprise, a driving bevel gear rotatably mounted on the body and driven from the power source by appropriate means, a second driven bevel gear rotatably mounted on the upright in conjunction with a means of changing the rotation of said second bevel gear through the angle required to drive the wheel (typically another pair of bevel gears) and the connection to the wheel, a drive shaft whose length may be variable, to which are irrotatably connected a futher pair of bevel gears which are held in mesh with the body and upright mounted bevel gears. There are several variations in mounting ;

a) The driving bevel gear on the body will be mounted coaxially with the body to horizontal link connection for one horizontal link or the mono tube link, the driven bevel gear will be mounted on the upright coaxially with the upright to horizontal link connection for the same horizontal link or mono tube link, the drive shaft will run in bearings located on/in the horizontal link/mono link or in bearings whose mounts pivot on or are coaxial with those of the meshing driven or driving bevel gear. This arrangement gives zero change in transmisssion means length when the vehicle banks.

N.B. The relative positioning of the gears is important if the wheel is not to rotate as the vehicle banks.(see diagrams in original patent).

b) The driving bevel gear will be rotatably mounted on the body along the line joining the two body to horizontal link connections or an extension thereof or 'vertically' above/below the mono tube link to body connection, the driven bevel gear will be rotatably mounted on the upright along the line joining the upright to horizontal link connections or an extension thereof in the same relative position as the driving bevel gear has to the body to horizontal link connections or the driven bevel gear will be mounted as far above/below the mono tube to upright connection the driving bevel gear was on the body. Also the axes of rotation of the driving and driven bevel gears will be longitudinal to the body. Where the driving and driven bevel gears are not coaxial with a horizontal link connection then the drive shaft will have to be mounted in bearings whose mountings pivot on or are coaxial with the axes of the driving and driven bevel gears, even so as the tolerances required of gears are very close, one of the drive gears may need to float axially along the shaft. It would be possible to use the drive shaft as a horizontal link of the suspension. This arrangement gives zero change in drive shaft length when the vehicle banks.

c) The driving bevel gear will be rotatably mounted on the body with a known offset from the line joining the two body to horizontal link connections or an extension thereof or at a known position relative to the mono tube link to body connection, the driven bevel gear will be rotatably mounted on the upright with the same offset from the line joining the upright to horizontal link connections or an extension thereof in the same relative position as the driving bevel gear has to the body to horizontal link connections or the driven bevel gear will be mounted at the same relative position to the mono link to upright connection as the driving has to the body to mono link connection. Also the axes of rotation of the driving and driven bevel gear may or may not be parallel and may or may not be longitudinal to the body.Where the driving and driven bevel gears are not coaxial with a horizontal link or mono link connection then the drive shaft will have to be mounted in bearings which pivot on or are coaxial with the axes of the driving and driven bevel gears, even so as the tolerances required of gears are very close at least one of the drive gears may need to float axially along the shaft. It would be possible rigidly fix the gears to the drive shaft and to use the drive shaft as a horizontal link of the banking suspension. N.B. If the driven and driving means do not have congruent positions then the drive shaft connecting them may need to be of variable length.

53) A Banking Suspension as claimed in claim 1 and claim 51 in which power is transmitted to drive each of the wheels of a banking suspension from a body mounted power source. This will require the sharing of the body mounted bevel gear/driving means or the provision of two body mounted bevel gears/driving means which may be irrotatably locked together, mounted coaxially or not, driven seperatly, rotate independantly in the same or opposite sense, or be connected by a differential.

CLAIMS RELATING TO STEERING THE DRIVEN WHEELS.

54) A Banking Suspension as claimed in claim 1 in which power is transmitted to drive at least one wheel which may also steer. To allow this there must be additional components provided on the upright, these shall comprise, a swivel or kingpin mounted upon the upright which shall carry the axle and it's wheel, a universal joint which shall connect the output of the drive means (usually the bevel gear mounted on the upright whose axis of rotation is for preference substantially parallel to the axis of rotation of the wheel when the vehicle is running straight ahead) to the wheel.

55) A Banking Suspension as claimed in claim 1 in which power is transmitted to drive at least one wheel which may also steer This alternative form is offered in which there must be additional components provided on the upright, these shall comprise, an upright which may swivel and carries the wheel, a bevel gear whose axis is coaxial with the wheel, a second bevel gear meshing with the first, a third bevel gear meshing with the second and which is universally joined to the, possibly variable length, drive shaft.

CLAIMS RELATING TO THE STEERING GEOMETRY OF A BANKING SUSPENSION.

56) A Banking Suspension as claimed in claim 1 in which, when the vehicle is upright and rotationally locked, the steering geometry is strongly analogous to that of a 'normal' double wishbone suspension (or solid axle or swing arms in the case of one piece upright to upright horizontal/mono links). The geometry may be parallel, ackerman, anti ackerman or of any other form. Claim is also made for steering geometry which mimics the geometry of a horizontal link/Mono link, but be moved fore or aft of the banking suspension in order to swivel the wheels by acting on extensions of the uprights. Also claimed is the possiblity of altering the relative steering angles of the wheels as the vehicle is rolled.

CLAIMS FOR VARIATIONS ON THE FRINGE OF UTILITY.

N.B. Claims 57 to 62 apply equally well to mono links.

57) A Banking Suspension as claimed in claim 1 in which, possibly due to the wheels being of small diameter, there may not be enough room to accomodate the required components within the wheel this problem can be overcome by ;
a) mounting the wheel on a fore/aft extension of the upright.
b) mounting the wheel on a horizontally extended upright which connects to two sets of horizontal links.
c) mounting the wheel on a horizontally extended upright which connects to two sets of interconnected horizontal links, this would be a more mechanically acceptable arrangement.
The idea may be adapted to work with mono links too.

58) A Banking Suspension as claimed in claim 1 in which the vehicle's body may be raised above the level of the wheels by extending it well above the body to horizontal link connections. This would allow the bulk of the vehicle to be high above the ground which may improve the vehicle's aerodynamics and allow the wheels to be mounted in a ground effect pod. This may be achieved by;
a) raising the body to horizontal link connection points relative to those of the upright to horizontal link connections.
b) raising the body to horizontal link connection points relative to those of the upright to horizontal link connections and extending the body upwards.
c) placing the upright to horizontal link connections above the wheels and connecting the body to the horizontal links at the same height. This minimises the effect of the ground on the vehicle.
d) placing the upright to horizontal link connections above the wheels and extending the body to the horizontal links upwards. This minimises the effect of the ground on the vehicle.

59) A vehicle equipped with a Banking Suspension as claimed in claim 1 in which the fact that as it is banked the vehicle has a means of 'knowing' what is horizontal exploits aerodynamic down force in a way that a motor bike may not. This would be done by attatching aerodynamic structures to the horizontal links or extensions thereof or forming the horizontal links into aerodynamic shapes. It is worth noting that the areodynamic structures will be closer to the ground as the angle of bank increases, where ground effect is required this could be an advantage. However if not desired a suitable system/linkage could give any height above ground to bank angle relationship required.

60) A vehicle equipped with a Banking Suspension as claimed in claim 1 which shall comprise two, or more of the 3 or 4 wheeled units claimed in claims 12 to 16, joined together to form a multiple vehicle. Said units may be fitted with at least one specially shaped wheel (tyre) to allow the vehicle to be run on surfaces that control the vehicles direction(rails). Wheel gyroscopic force cannot balance this type of vehicle and which must be leaned by applying torque between at least one horizontal link and the body or by applying torque between at least one horizontal link and at least one upright or the equivalent for a mono link. A body mounted gyroscope may be used to provide the torque. To accomodate variations in track width it would be possible to alter the effective length(s) of at least one of the horizontal links, or the track must be compliant or one wheel in each pair must run on a substantially flat track.

61) A Banking Suspension as claimed in claim 1 in which there is compliance in bump/droop. If it is desired to allow some degree of rearward movement of a wheel as it strikes a bump, there are many methods by which this could be done some are detailed below.
a) use of a body mounted subframe(which carries both horizontal half links for a side) pivoted 'vertically' and sprung against rotation that would allow rearward movement of the wheels.
b) use of a compressible/extensible wishbone wherein a forward/rearward facing wishbone carrying either an individually mounted horizontal link or acting in conjunction with a subframe will change in length to provide the complience required.
c) use of an extra member between upright and wheel, which pivots on an axis perpendicular to the direction of motion/wheel travel and whose rotation allows the desired complience.
d) use of four subframes as in a) but each carrying only one half horizontal link.

62) A Banking Suspension as claimed in claim 1 where alternative linkages are used to achieve the same goals. They are detailed below;
a) A banking suspension where the body connects to only one horizontal link and an additional link is run from one upright (for preference from an existing upright to horizontal link connection) to the body, to control the angular disposition of the body and the upright. In this case the additional link is parallel to the horizontal links and the body and upright move through the same angle.
b) A banking suspension where the body connects to only one horizontal link and an additional link is run from one upright to the body, to control the angular disposition of the body and the upright. In this case the additional link is not parallel to the horizontal links and the body and upright move through different angles.
c) A banking suspension where the body is not connected to any horizontal link and two additional links are run from one upright to the body, to control the angular disposition of the body and the upright. In this case the additional links are parallel to the horizontal links and the body and upright move through the same angle. Clearly the links could be none parallel and arranged to produce a none linear angular relationship between body and upright.
d) A banking suspension where the body is not connected to any horizontal link and two additional links are run one from each upright to the body forming a Watts linkage with the body as one of the members, which controls the angular disposition of the body and the uprights. In this case the additional links are parallel to the horizontal links and the body and uprights move through the same angle. Clearly the links could be none parallel and arranged to produce a none linear angular relationship between body and upright. It would be possible to attatch the center point of the above watts linkage to one of the horizontal links or for it to be sprung on one of the horizontal links.
e) A banking suspension where the body is connected to one horizontal link and two additional links are run one from each upright and in conjuction with two 'third' links they form a pair of Watts linkages. These are attatched to the body to control the angular disposition of the body and the uprights. The additional links may be arranged to move the body and uprights move through the same angle or not as desired.

Patents Act 1977 Examiner's report to the Comptroller under Section 17 (T Search report) -40	Application number GB 9312453.5
Relevant Technical Fields (i) UK Cl (Ed.L) B7D (DCF) (ii) Int Cl (Ed.5) B62D 9/02	Search Examiner COLIN THOMPSON Date of completion of Search 13 OCTOBER 1993
Databases (see below) (i) UK Patent Office collections of GB, EP, WO and US patent specifications. (ii)	Documents considered relevant following a search in respect of Claims :- 1 AT LEAST

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Category	Identity of document and relevant passages		Relevant to claim(s)
X	GB 2155411 A	(HONDA)	1 at least
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